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REMEDIAL INVESTIGATION
PHASE I REPORT

EXISTING LITERATURE REVIEW
AND EVALUATION

CHEROKEE COUNTY SITE
KANSAS

December 18, 1984

CH2M HILL PROJECT
NO. W67201.00

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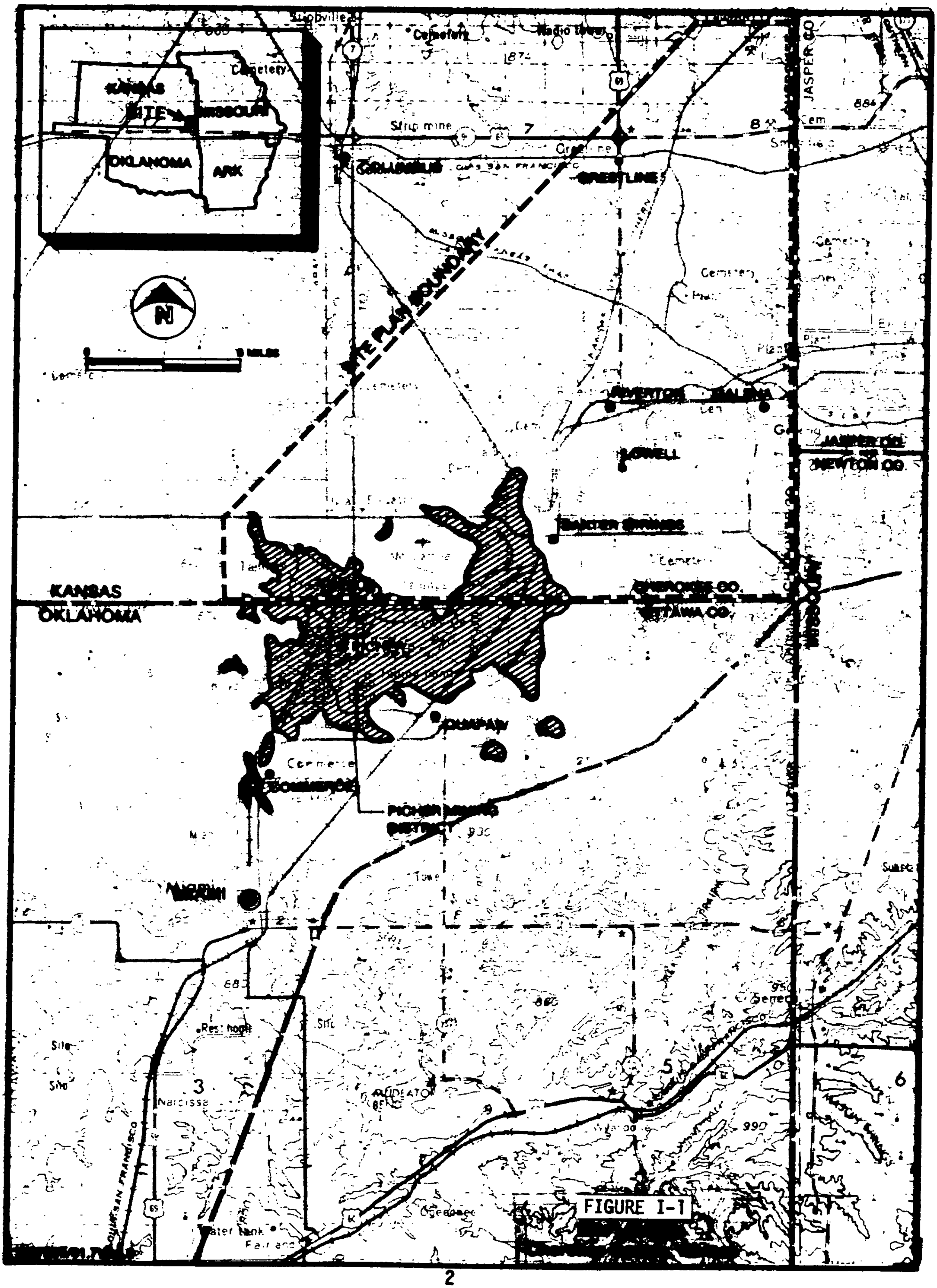
I. INTRODUCTION

A. PURPOSE OF STUDY

The purpose of the planned Remedial Investigation at Cherokee County is to assess the nature and extent of environmental impacts caused by mining activities in a portion of the Tri-State Mining area, and to identify the subsequent problems associated with water quality degradation, acid mine drainage, subsidence and other geologic hazards, erosion of tailings piles, air quality impacts and other environmental problems. The study will specifically address impacted portions of Cherokee County, Kansas and will assess how those past mining activities in this area are currently impacting the environment or posing a significant health hazard.

The Cherokee County site is in a region known as the Tri-State Mining District, an area which encompasses about 500 square miles. The Tri-State Mining District includes portions of Cherokee County, Kansas; Ottawa County, Oklahoma; and Jasper County, Missouri. Figure I-1 shows the Cherokee County site boundaries identified in the Phase I Work Plan. As a result of this study, site boundaries were redefined as described in Section IX of this report.

During preparation of the Remedial Action Master Plan (RAMP) for the Cherokee County site, a substantial amount of existing data and literature was identified, but only part of this information was obtained and reviewed because of the limited scope and budget of the RAMP process. It was also evident that more literature was likely available from many of the State and Federal agencies, universities, or research organizations in the area as a result of past and recent studies within this large mining district. Additionally, several ongoing studies were identified that have recently reported their results or have compiled data that was not obtained during the RAMP process. For example, the Remedial Investigation and Feasibility Study for the Tar Creek site (the southern extent of the Tri-State District) investigated under the direction of the EPA Region VI and the Tar Creek Task


KANSAS
MISSOURI
OKLAHOMA
ARK
SITE
SITE PLAN BOUNDARY
5 MILES
N
JASPER CO.
CHEROKEE CO.
OTTAWA CO.
NEWTON CO.
KANSAS
OKLAHOMA
COLUMBUS
CRESTLINE
RIVERTON
GALENA
LOWELL
BAXTER SPRINGS
QUAPAW
COMMERCE
PICHER MINING DISTRICT
MIAMI
Strip mine
Cemetery
Radio tower
Narcissa
Rest home
Water tank
Fairland
FIGURE I-1

Force was recently completed; a Water Resources Report on the effect of lead and zinc mining on water resources of Cherokee County and adjacent areas was recently completed by the U. S. Geological Survey; and air quality monitoring was being conducted by the Kansas Department of Health and Environment.

This existing literature review was therefore performed to assemble the existing scientific literature and data and to evaluate the accuracy and usefulness of the data as related to a determination of how the Cherokee County site is impacting the environment or posing a significant health hazard. The available data and scientific literature (published and unpublished) from prior and ongoing studies was gathered, reviewed, and compiled into a data base for site charaterization and eventual development of work plans for further phases of the project. A site visit was also performed to familiarize the study team with the site and to assist in proposing a site boundary.

B. STUDY LIMITATIONS

This literative review included contacting Federal and State agency personnel in Kansas, Missouri, and Oklahoma to identify and obtain the relevant scientific literature on the Tri-State Mining area. Over two dozen interviews were conducted during the week of October 8, and an additional 10 to 15 contacts were made by telephone during that and the following weeks. The available literature was then reviewed and evaluated, and a draft report was completed by October 26. In that same time period, the project staff conducted a three-day site visit.

A few secondary contacts and literature sources identified during the agency contacts and literature collection were not available for contact or could not be critically reviewed during the report preparation period. Some of the planned agency contacts were not able to be made due to prior commitments, job related travel, or vacations. Thus, a few additional data or reports may be available which are not included in this report. Since many of the reports reviewed were in summary form, specific collection and analytical methods, quality assurance/quality control procedures and general availability of raw or supporting laboratory data could not be critically reviewed.

Because of the schedule and budget constraints, a complete and exhaustive search and evaluation of all existing data was not possible. However, the data identified during this search that is appropriate for inclusion into the RI/FS data base will be studied more thoroughly during preparation of the work plan for the Remedial Investigation.

C. REPORT FORMAT

The main focus of this report is to provide an evaluation of whether the existing data is sufficient to allow for only limited field studies prior to the performance of a feasibility study. About 275 references, some of them only short memos or letters, were reviewed and evaluated. In each section, a general description of each data area is provided, followed by a discussion of the significant details of the data. Much of the presentation of the data sources is provided in a tabular format which addresses sample location, accuracy, period of record, number of observations, and sampled parameters.

An evaluation of the data is then provided relative to suitability for the performance of the Remedial Investigation/Feasibility Study. Each section is closed with an annotated bibliography of significant data sources. A complete bibliography and list of agency contacts performed is provided in the Appendices to this report.

II. GEOLOGY AND MINING

A. GENERAL GEOLOGY

Because of mining activity and reliance upon groundwater in the area, a number of geologic studies have been performed. Brichta (1960) was able to assemble logs for 95,721 borings done throughout the Tri-State Mining District. These logs are held on microfiche at the Kansas Geological Survey Office in Lawrence, Kansas. Drillers logs for a dozen water wells in Cherokee County were available through KDHE. Studies have been performed to interpret ore reserves (Brockie, et al., 1967; Siebenthal, 1907; Siebenthal, 1915). Additional studies have been undertaken to evaluate groundwater resources (Reed, et al., 1955; Hittman Assoc., 1981; Abernathy, 1941; Abernathy, 1943; Spruill, 1984).

Cherokee County occupies both the Ozark Plateau and Interior Lowlands physiographic provinces. The dividing line between the provinces is approximately the Spring River, with the Ozark Plateau to the east and the Interior Lowlands to the west.

The site is on the western flank of the Ozark Uplift. Strata dip westward at less than one degree. Other, less extensive structural features are also present (Figure II-1); the most notable of these is the Miami Trough (Brockie, et al., 1967). The Miami Trough is a combination syncline/graben structure which trends N 30° E through Picher, Oklahoma.

The stratigraphic nomenclature in the Cherokee County area is complex. Because many of the formations present are similar in nature, and because informal stratigraphic names vary across the Tri-State Mining District, formation names have changed through time. Figure II-2 summarizes some of the stratigraphic nomenclature used in the past. For purposes of this study, the nomenclature of the most recent USGS publication, Spruill (1984), will be used.

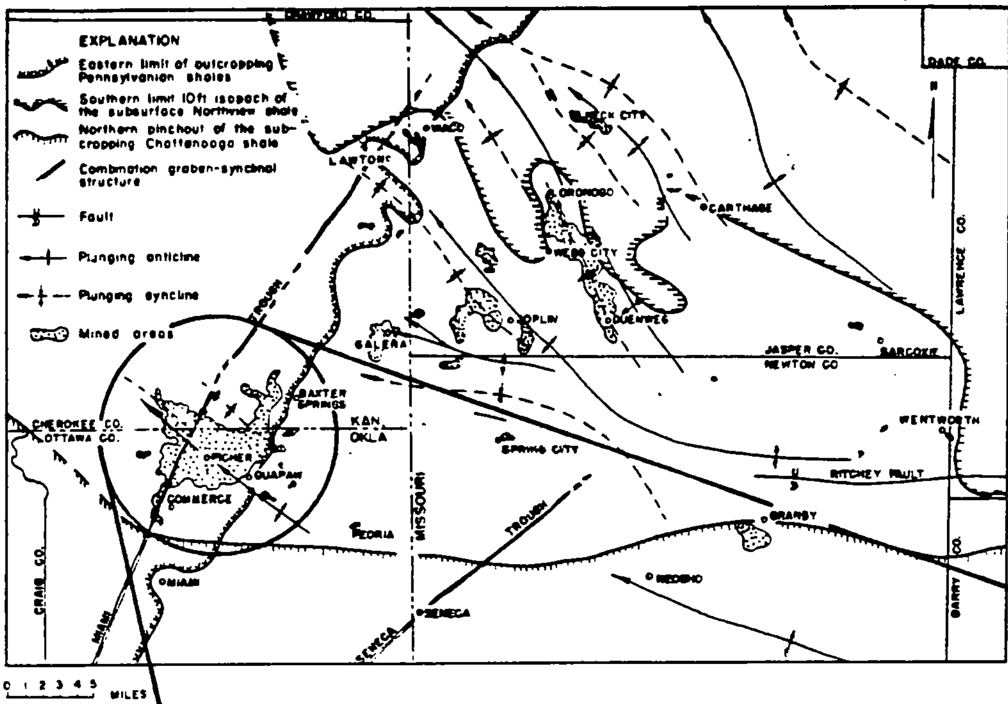
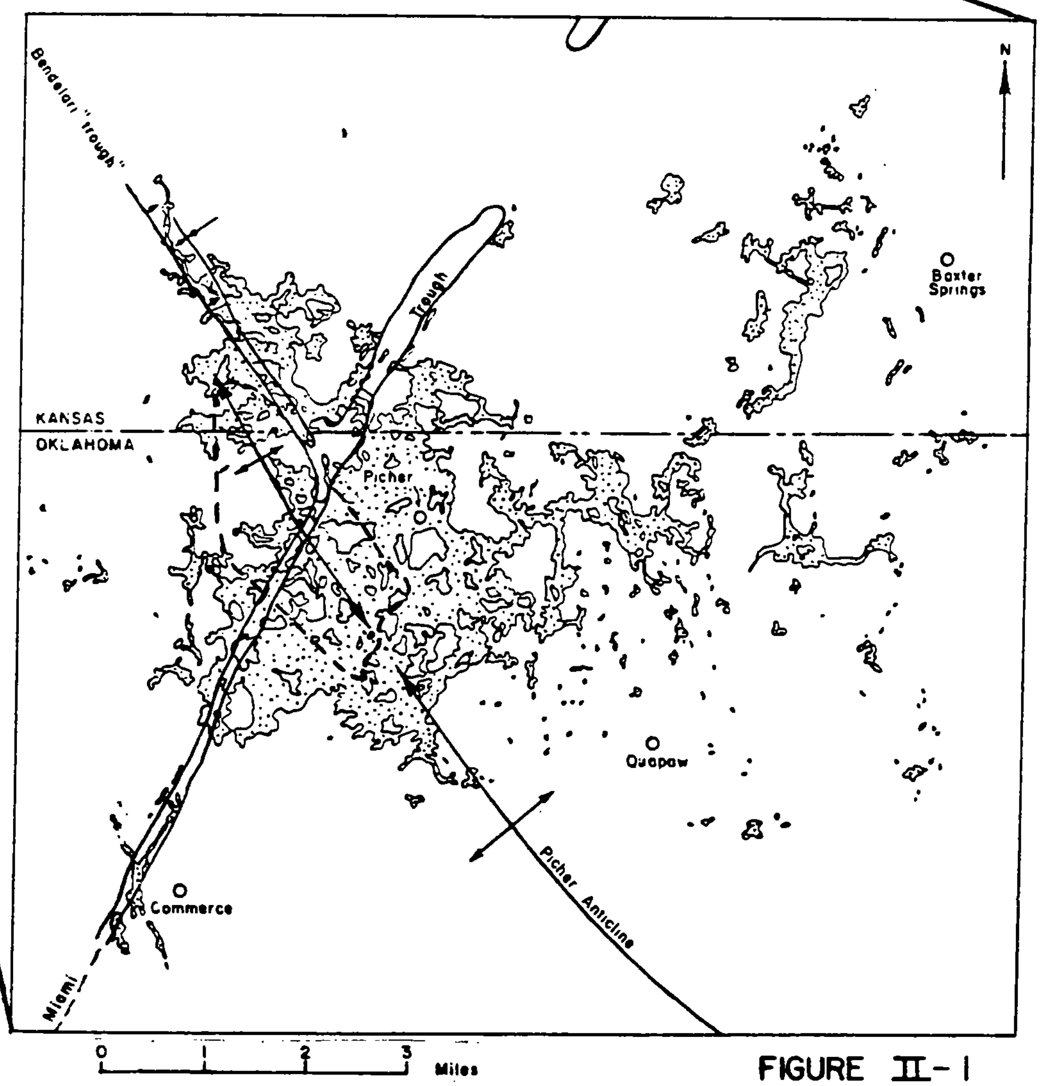


FIG. 1. *Map of the Tri-State District, showing the major structural and geological features.*



Map of Picher Field, showing underground mine workings and axes and outlines of the principal structural features. A large broad dome is shown by the dashed lines.

FIGURE II-1

SOURCE: BROCKIE, et al., 1967	GEOLOGIC STRUCTURES IN THE TRI-STATE MINING DISTRICT
SRW ASSOCIATES INC. PITTSBURGH, PA 6	DATE: OCT. 24, 1984 / DR.: M. MARKS
	SCALE: AS SHOWN / DWG. NO.: 84265-A

SYSTEM	MacFarlane et al. (1981)	Reed et al. (1955)	Ireland (1930)	Spruill (1984)	McCauley et al. (1983)	Sibenthal (1915)	Brockie (1967)	OWRB (1983)	Abernathy (1941)	Marcher & Bingham (1971)
MISSISSIPPIAN	Undifferentiated Northview Shale Compton Limestone	Fayetteville Shale Batesville Ss Hindsville Ls Boone Formation Northview Shale Compton Limestone	Fayetteville Fm Mayes Ls Boone Chert and Limestone Chattanooga Shale	Undifferentiated Warsaw Limestone Burlington-Keokuk Ls Fern Glen Limestone Northview Shale Compton Limestone	Undifferentiated Warsaw Limestone Keokuk Limestone Fern Glen Limestone	Carterville: Fayetteville, Batesville Boone Formation	Fayetteville Shale Batesville Sandstone Hindsville Warsaw Fm Keokuk Fm Reeds Spring Fm St. Joe Group: Fern Glen Fm, Northview Shale, Compton Ls	Fayetteville Fm. Mayes Formation Boone Formation	Warsaw Limestone Cowley Fm Keokuk Ls Reeds Spring Ls St. Joe Ls Northview Shale Compton Limestone	Pitkin Fm Fayetteville Fm Batesville Fm Hindsville Fm Morefield Fm Keokuk Fm Reeds Spring Fm St. Joe Group
DEVONIAN	Chattanooga Shale	Chattanooga Shale	Absent	Chattanooga Shale		Chattanooga Shale	Chattanooga Shale	Chattanooga Shale	Absent	Chattanooga Fm
ORDOVICIAN	Powell Fm Cotter Formation Jefferson City Formation Roubidoux Formation Upper and Lower Gasconade Dolomite Gunter Sandstone	Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Formation Gunter Sandstone Member	Tyner Shale Burgen Ss Unnamed Limestone and Dolomite	Arbuckle Group: Cotter-Jefferson City Dolomite, Roubidoux Formation, Gasconade Dolomite		Kimmswick ? Joachim ? ? St. Peter ? ? Jefferson City Roubidoux Gasconade	Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Dolomite Gunter Member	Cotter Dolomite Jefferson City Dolomite Roubidoux Formation	Cotter Dolomite Jefferson City Dolomite Roubidoux Sandstone Van Buren-Gasconade Dolomite Gunter Sandstone	Fernvale Fm Fite Fm Tyner Fm Burgen Ss Cotter Fm Absent

FIGURE II-2: CORRELATION OF STRATIGRAPHIC NOMENCLATURE USED BY PREVIOUS AUTHORS

Table II-1 is a generalized stratigraphic section of Cherokee County. The Ordovician, Devonian, and Mississippian strata are of greatest interest to the Remedial Investigation. The Ordovician rocks are largely dolomites and sandy dolomites. The Devonian period is represented by the Chattanooga Shale, which is commonly absent in the study area. The Mississippian sediments are shales near the base of the section, and carbonates higher in the section. Aquifers occur in Ordovician and Mississippian strata; these will be discussed more fully in Section III.

Ore bodies in the Tri-State Area most commonly occur within specific beds of the Warsaw and Keokuk Limestones, and are generally associated with chert beds (Brockie, et al., 1967; Siebenthal, 1915; Brichta, 1960). The ores are believed to have been deposited by deep circulating groundwaters, and are frequently associated with structural discontinuities such as folds, fractures, and brecciated zones. The largest ore bodies are associated with the Miami Trough west of Baxter Springs and with an unnamed anticline passing through Galena. Mining has caused the formation of collapse breccias. These breccias, as well as natural breccias and structural discontinuities with which the ores are associated, result in zones of anomalously high permeability (further discussed in Section III.B).

Predominant minerals within the ore bodies are galena (lead sulfide), sphalerite (zinc sulfide), and pyrite and marcasite (both iron disulfide). Even under natural conditions, it would be expected that the presence of these minerals would cause native groundwaters to have some concentration of the elements involved. The opening of mine workings would allow extensive oxidation of the ore minerals, releasing potentially large quantities of iron, lead, zinc, and sulfide to the groundwater system, along with sulfuric acid formed by the resultant chemical action. Asphalt also sometimes occurs in association with ore bodies (Ireland, 1930). In form, ore bodies occur as "sheet ground" (horizontal slabs) and "long runs" (veins). The form of mining used was a modified room-and-pillar, worked outward from a vertical shaft.

TABLE II-1

GENERALIZED STRATIGRAPHIC COLUMN FOR CHEROKEE COUNTY, KANSAS

System	Formation	Lithology	Thickness
Pennsylvania	Undifferentiated	Shales and Sandstones with Coal	0-450
Mississippian	Undifferentiated	Limestones, Shales, and Siltstones	0-120 (Generally Absent)
	Warsaw Limestone	Crinoidal Limestone with Chert	0-180
	Burlington-Keokuk Limestone	Coarse Crystalline Limestone with Chert	20-240
	Fern Glen Limestone	Upper Portion: Limestone with Chert Lower Portion: Dolomitic Limestone	120-200
	Northview Shale	Calcareous Shale	0-55
	Compton Limestone	Shaley Limestone	0-25
Devonian	Chattanooga Shale	Black Shale	0-10 (Generally Absent)
Ordovician	Cotter-Jefferson City Dolomite	Cherty Dolomite and Sandstone, with Shale Partings	170-550
	Roubidoux Formation	Sandy Dolomite with Chert	120-200
	Gasconade Dolomite	Coarsely Crystalline Dolomite, Sandy in Lower Portion	165-320
Cambrian	Eminence Dolomite	Coarse-Grained Dolomite with Glauconite and little Chert	120-210
	Bonneterre Dolomite	Medium- to Fine- Crystalline Dark Dolomite	140-230

NOTE: The Ordovician strata, plus the Éminence Dolomite, comprise the Arbuckle Group.

SOURCE: Spruill, 1984.

B. MINING

Ore was first discovered in the Tri-State Mining District in 1848. The first substantial mine in Kansas was at Galena; ore was discovered there in 1876. From that time, lead-zinc mining in Cherokee County flourished until 1970, when the Swalley Mine near Baxter Springs closed. The total output of the Tri-State Mining District from 1850 to 1958 was valued at more than 2 billion dollars. (Brichta, 1960; Brockie, et al., 1967; McCauley, et al., 1983)

It is unknown how quickly mining spread throughout Cherokee County. Seibenthal (1915) depicts only five mines in Kansas at that time, all of them located on the Mississippian outcrop. Ore reserves, but no active mines, were noted at Pittsburg and Columbus. Table II-2 is a brief chronology of mining in Cherokee County.

Brichta (1960) and McCauley et al. (1983) both did extensive work to determine the location and extent of abandoned mine workings. The data compiled by Brichta is available for inspection at the U. S. Bureau of Mines office. McCauley's work was compiled on a set of USGS 7-1/2 minute quadrangle maps included with that report. Also, the library at Missouri Southern State College, in Joplin, houses the Tri-State Mining District Mine Map Repository, where all known mine maps are kept on file. Although all data available have not been compiled on a single map, sufficient information is available to do so.

McCauley, et al. (1983) also examined stereo pairs of aerial photographs and compiled maps of existing physical hazards - subsidence, chat piles, and open shafts - onto USGS quadrangle maps.

When the mines were active groundwater was continually pumped to keep the workings dry. Effects of this pumpage are discussed in Section III.

TABLE II-2

CHRONOLOGY OF MINING IN CHEROKEE COUNTY, KANSAS

1871	Extension of St. Louis and San Francisco Railway into Kansas provides a transportation route for area
1876	Discovery and first mining of ores at Galena
1878	First smelters built at Galena
1889	Development of mines in Badger-Peacock area
Circa 1900	Ore discovered at Lawton
1910	First mines at Lawton
1916	Opening of mines near Baxter Springs and Blue Mound
1917	Mining begins in the Kansas portion of the Waco area; Beginning of peak production years which lasted until 1945
Circa 1925	Flotation process of ore refining became commonplace, increasing the previous milling efficiency which averaged 63% and frequently fell below 50%. Reprocessing of old tailings began to contribute substantially to the total metal output. Eagle-Picher Company installed the first large, central mill, eliminating the need for a mill on each mining property.
1926	Maximum production year. Cherokee County produced 28,000 tons of lead and 126,000 tons of zinc.
1958	Sagging metal prices forced closing of the mines.
Early 1960's	Reopening of mines
1970	Swalley Mine near Baxter Springs becomes the last lead-zinc mine to permanently close.

SOURCES: Brichta, 1960; Brockie, et al., 1967; McCauley, et al., 1983

III. GROUND WATER RESOURCES

A. GENERAL HYDROGEOLOGY

Historically, hydrogeology of the Tri-State Mining District has been thought of as primarily consisting of two aquifers - the Boone and the Roubidoux as shown previously in Figure II-2 (Abernathy, 1941; Reed, 1955; OWRB, 1983, Task I.4). However a broader look at the stratigraphic sequence present indicates that the groundwater system includes a shallow aquifer comprised of the Mississippian units above the Northview Shale; a deep aquifer comprised of the Arbuckle Group and older sediments; a shallow aquitard comprised of the Pennsylvanian and uppermost Mississippian units; and a deep aquitard comprised of the Northview Shale, the Compton Limestone, and the Chattanooga Shale. Where the units forming the deep aquitards are absent, the shallow and deep aquifers actually become a single aquifer (Spruill, 1984; MacFarlane, *et al.*, 1981).

B. SHALLOW AQUIFER

1. *General Information:*The shallow aquifer includes the Warsaw Limestone, the Burlington-Keokuk Limestone, and the Fern Glen Limestone. This aquifer is equivalent to the Boone aquifer of some previous authors. Average thickness of the aquifer is approximately 350 ft. The shallow aquifer is very heterogeneous. West of Spring River, where Pennsylvanian rocks are present, it is under confined conditions; east of Spring River, where the limestones outcrop, the aquifer is under water-table conditions. Brecciated zones occur, especially near Galena, and these act as zones of anomolously high and variable permeability zones in the shallow aquifer (Spruill, 1984). As examples, Hittman Associates (1981) estimated the transmissivity of the shallow aquifer as 35,000 gpd/ft., whereas Spruill (1984) estimates it as less than 800 gd/ft., except in brecciated zones where transmissivity may be 8,000 gpd/ft. or greater. As further examples, Reed, *et al.* (1955) cites well yields in the shallow aquifer in excess of 1,000 gpm,

whereas MacFarlane, et al. (1981) cites well yields as typically 25 gpm, with a maximum value of 100 gpm. Spruill (1984) estimates the storage coefficient as 2×10^{-4} for unconfined conditions and porosity as 5%, but these are not measured quantities.

During the time that the lead-zinc mines were active, groundwater was being continually pumped at a very high rate (Reed, et al., 1955). Abernathy (1941) reports single mines pumping as much as 2 mgd to keep the workings dry. The result of this prolonged pumping was the creation of a very large cone of depression in the shallow aquifer, with groundwater constantly flowing into the mining districts. Water levels in the shallow aquifer began to rise when mining ceased, and apparently stabilized in approximately 1980 (OWRB, 3/83, Task I.4).

Where the aquifer is unconfined, the water table approximates the ground surface, with groundwater discharging to surface-water bodies. Where the aquifer is confined, flow is generally northwestward (Spruill, 1984).

In addition to normal groundwater flow in the shallow aquifer, water moves through abandoned mine workings which are filled or partially filled with water where they occur below the water table. Water from mines does discharge to surface water, but detailed flow within the mines has not been studied.

2. Data Available: There are two types of water quality data available: analyses of well water, and analyses of water in the mine workings. The water in abandoned mines is acid mine drainage (AMD).

Until recently, groundwater was discharging into mine workings because of pumping. In most instances, groundwater moves very slowly. Therefore, AMD from mines would not be expected to have moved far from them in the years since mining has ceased. For this reason, even recent chemical analyses of well water probably represent background water quality. Shallow groundwater is of the calcium-bicarbonate type, moderately hard, and low in total dissolved solids (Reed, et al., 1955). Such waters have good buffing capacity, and should limit the extent of AMD in the groundwater by neutralizing the acid.

Known sample locations and analytical data are summarized in Table III-1. Water-level observations are summarized in Table III-2. The heading "Map Location" denotes whether or not the exact location of the data point is known and can be located on a map.

3. Data Evaluation: Data on the hydrogeology of the shallow aquifer is inadequate for purposes of the RI/FS. The transmissivity values cited above are insufficient for understanding of the entire aquifer; the various authors disagree on values of major aquifer parameters. Chemical data on water in mine workings and background water quality is sufficient, but groundwater quality near the mine workings is unknown. Although the regional groundwater flow pattern is known, the specific flow direction in the vicinity of the mine workings is not known. The groundwater flow velocity, hence the rate of contaminant migration, is unknown. The hydraulic relationship between mine workings and the aquifer is unclear from available data.

C. DEEP AQUIFER

1. General Information: The deep aquifer occurs in the dolomites and sandstones of the Arbuckle Group and older sedimentary formations. This aquifer includes the Roubidoux Formation, often treated as an aquifer unto itself by other authors. The Roubidoux is probably the most productive zone of the deep aquifer. Thickness of this aquifer generally exceeds 1,000 ft.

   The aquifer is generally under confined conditions, although it may be only semi-confined where the units comprising the deep aquitard are

TABLE III-1

SUMMARY OF KNOWN ANALYSES OF SHALLOW GROUNDWATER
IN CHEROKEE COUNTY, KANSAS

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
Borehole to Burlington-Keokuk 125' Depth	Yes	12/26/41	Fe, Mn, Ca, Mg, Na+K, HCO_3, SO_4, Cl, F, NO_3, TS, Insoluble Residues, Alkalinity, Hardness	Abernathy (1943)
Borehole to Reeds Spring 175' Depth	"	12/28/41	"	"
Borehole to Reeds Spring 244' Depth	"	12/30/41	"	"
Lucky Jew Mine Shaft, Sampled Collect at 8 Depths	Yes	4/27/76	pH, T, Sp.Cond.,Ca,Mg,Na K, Hardness, Non-Carbonate Hardness, Turbidity, Acidity, Alkalinity, Sodium Absorption, HCO_3, CO_3, SO_4, Cl, F, SiO_2, TDS, TSS, NO_3, NO_2, NH_3, Al, Total Al, As, Total As, Ba, Total Ba, Bo, Total Bo, Cd, Total Cd, Cr, Total Cr, Co, Total Co, Cu, Total Cu, Fe, Total Fe, Pb, Total Pb, Li, Mn, Total Mn, Hg, Total Hg, Mo, Total Mo, Ni, Total Ni, Se, Total Se, Zn, Total Zn, TOC, MBAS	Playton, et al. (1980)
Lucky Jew Mine Shaft, Sampled at 4 Depths	"	10/21/76	"	"
Lucky Jew Mine Shaft, Sampled at 8 Depths	"	6/9/77	"	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-1 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
USGS Sta. 370558094370001 (Well)	Yes	8/12/81	pH, Sp.Cond., T, Ca, Mg, Na, K, SO_4, Alkalinity, Cl, F, SiO_2, TDS, NO_3, As, Ba, Cd, Cu, Fe, Pb, Mn, Se, Zn	Spruill (1984)
USGS Sta. 370032094411301 (Well)	"	3/18/82	"	"
USGS Sta. 370108094390101 (Well)	"	7/31/81	"	"
USGS Sta. 370124094390501 (Well)	"	7/31/81	"	"
USGS Sta. 370408094401201 (Well)	"	7/30/81	"	"
USGS Sta. 370428094405401 (Well)	"	3/16/82	"	"
USGS Sta. 370428094424401 (Well)	"	7/31/81	"	"
USGS Sta. 370639094391201 (Well)	"	3/16/82	"	"
USGS Sta. 371830094444201 (Well)	"	3/18/82	"	"
USGS Sta. 371051094474701 (Well)	"	7/31/81	"	"
USGS Sta. 370120094522101 (Mine)	"	11/20/81	Sp.Cond., pH, T, DO, Ca, Mg, Na, K, Alkalinity, SO_4, Cl, F, SiO_2, TDS, NO_3, As, Ba, Cd, Ca, Fe, Pb, Mn, Se, Zn	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-1 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
USGS Sta. 370134094515701 (Mine)	Yes	12/8/81	" (Except TDS)	Spruill (1984)
USGS Sta. 365951094464901	"	12/7/81	"	"
USGS Sta. 370108094455201 (Mine)	"	12/8/81	" (Except NO_3)	"
USGS Sta. 370107094462401 (Mine)	"	12/7/81	" (Except Alkalinity)	"
USGS Sta. 370213094472501 (Mine)	"	11/20/81	"	"
USGS Sta. 370213094472501 (Mine)	"	3/16/82	"	"
USGS Sta. 370056094511101 (Mine)	"	11/17/81	" (Except T, DO, F)	"
USGS Sta. 370146094465401 (Mine)	"	3/17/82	" (Except TDS, NO_3)	"
USGS Sta. 370109094510701 (Mine)	"	8/13/81	" (Except DO)	"
USGS Sta. 370120094505301 (Mine)	"	3/17/81	" (Except NO_3)	"
USGS Sta. 370232094460101 (Mine)	"	3/18/82	" (Except NO_3)	"
USGS Sta. 370447094381301 (Mine)	"	8/11/81	" (Except DO, TDS)	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-1 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
USGS Sta. 370447094381301 (Mine)	Yes	3/15/82	" (Except DO, NO_3, Sp.Cond., DO, Ca, Mg, Na, K)	Spruill (1984)
USGS Sta. 370527094365701 (Mine)	"	8/12/81	" (Except Alkalinity, TDS)	"
"	"	11/19/81	" (Except T, DO, Alkalinity, F)	"
USGS Sta. 370520094365703 (Mine)	"	8/12/81	" (Except Alkalinity, TDS)	"
USGS Sta. 370520094365702 (Mine)	"	8/12/81	" (Except Alkalinity, TDS)	"
USGS Sta. 3704410994371401 (Mine)	"	8/13/81	" (Except NO_3)	"
USGS Sta. 370447094384701 (Mine)	"	8/14/81	" (Except TDS, DO)	"
"	"	3/16/82	" (Except NO_3)	"
USGS Sta. 370448094385501 (Mine)	"	8/14/81	" (Except Alkalinity, TDS)	"
USGS Sta. 370415094381301	"	8/12/81	" (Except Alkalinity TDS)	"
Well at Location 32-22E-1DDA	"	8/27/64	Sp.Cond., TDS, Ca, Mg, Na, K, Cl, SO_4, HCO_3, SiO_2	"
Well at Location 32-23E-24AD	"	9/9/64	"	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-1 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
Well at Location 32-24E-27DDD	Yes	9/8/84	"	Spruill (1984)
Well at Location 32-24E-30AAA	"	9/9/64	"	"
Well at Location 32-25E-36ADDD	"	11/8/63	"	"
Well at Location 34-25E-04ABD	"	1/19/42	TDS, Ca, Mg, Na, Cl, SO_4, HCO_3	"
Well at Location 34-24E-31CD	"	1/19/42	"	"
Riverton School District 404	Yes	12/13/80	Ca, Mg, Na, Cl, SO_4, NO_3, F, Fe, Hardness, Alkalinity, Mn	KDHE (1984)

NOTE: Analyses for Dissolved Constituents Unless Otherwise Noted

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

TABLE III-2

SUMMARY OF AVAILABLE WATER LEVEL DATA
CHEROKEE COUNTY, KANSAS

Date/Period of Observation	Location	Aquifer	Map Location[1]	Data Source
2/42	Jayhawk Ordinance Works	Deep	Yes	Abernathy (1943)
9/75-6/77	7 Mines in KS & OK	Shallow	Yes	Playton, *et al.*, (1980)
1976-1984	Misc. Cherokee County Water Wells	Unspecified	No	KDHE (1984)
3/54-3/55	Pittsburg, KS	Deep	No	Stramel (1951)
1942-1982	Misc. Cherokee County	Both	Yes	Spruill (1984)

1 - Yes, indicates a map location for the sampling site is available.

absent (Spruill, 1984). Transmissivity of the aquifer varies areally, and reported values range from 24,000 to 260,000 gpd/ft. (Reed, *et al.*, 1955; Stramel, 1975). These values were calculated from pumping tests, as were storage-coefficient values ranging from 3 x 10^{-3} to 4 x 10^{-5}. The Oklahoma Water Resources Board (OWRB 1983, Task I.4) asserts that Reed's calculations are incorrect, but presents no alternative values. MacFarlane, *et al.* (1981), cites transmissivities in the Tri-State Region which range from 375 to 225,000 gpd/ft., but does not present the source of this data. Abernathy (1943) presents pumping test data from which aquifer properties could be calculated, but did not present any transmissivity or storage values.

Near the turn of the century, flowing wells in the deep aquifer were not uncommon, and the piezometric surface on the deep aquifer probably stood approximately 800 ft. above mean sea level, or 100 ft. below the mean ground surface elevation of 900 ft. (Siebenthal, 1915; Reed, *et al.*, 1955). Natural direction of groundwater flow was probably westward (MacFarlane, *et al.*, 1981). Heavy pumping has lowered the piezometric surface of the deep aquifer so that it now ranges between 550 and 800 ft. in most of Cherokee County. Groundwater flow beneath the mining district is generally southwestward. The flow direction in the deep aquifer is dominated by a large cone of depression centered in Ottawa County, Oklahoma, and assumed to be due to public and industrial water withdrawal (Spruill, 1984; MacFarlane, *et al.*, 1981).

During recent years, as the piezometric surface in the deep aquifer has been decreasing due to pumpage, the piezometric surface on the shallow aquifer has been rising due to the cessation of mining (Spruill, 1981; MacFarlane, *et al.*, 1981). These changes act together to increase the hydraulic gradient across the deep aquitard, which will in turn increase the rate and quantity of flow through that aquitard. The possibility of contaminated groundwaters migrating from the shallow aquifer to the deep aquifer is accentuated where the confining layers are absent (Spruill, 1984; MacFarlane, et al., 1981; Reed, et al., 1955). Spruill (1984) estimates downward leakage between aquifers at 3 billion gallons per year (6,000 gpm) over the 735 square mile mining district. This value translates to only 8 gpm/sq. mile and, according to Spruill, suggests that vertical leakage is not currently an important source of recharge water to the deep aquifer.

Problems with vertical leakage, to date, have been much more significant in individual wells (Williams, 1984; Reed, et al., 1955; OWRB, 1983, Task II-2). Acid mine waters can corrode well casings or seep downward around improperly set casings. Abernathy (1948) refers to several deep wells which were abandoned due to contamination with what he presumed were saline waters from the Cherokee Shale. Reed, et al. (1955) notes that about 100 deep wells have been intersected by mining activities, and recommends plugging of the wells. OWRB (1983, Task II.2) found definite evidence of AMD leakage in two deep wells, and possible evidence in another well.

Whether leakage in individual borings is a significant areal problem is a matter of controversy: Thomas (1984) includes comments by Eagle-Picher Industries which points out the lack of specific data on the subject and the possibility of natural neutralization of AMD with water of the deep aquifer. Spruill (1984), on the other hand, estimates that as much as 364 million gallons per year (700 gpm) could migrate between the aquifers through a single 7 in. diameter borehole.

2. Data Available: Water quality data on the deep aquifer are abundant. Reed, et al. (1955) calls the waters a calcium-bicarbonate type. Marcher and Bingham (1971) show deep groundwater in Oklahoma as varying from a calcium-magnesium-bicarbonate type to a sodium-chloride type. The similarity between the geochemical "fingerprints" of shallow wells and some deep groundwater may possibly, but not necessarily, suggest an

interaction betwen the aquifers in certain localities. Similar fingerprints presented by Spruill (1984) do not show the same similarity between aquifers. Available analyses of deep groundwater in Cherokee County are summarized in Table III-3. Water level observations are summarized in Table III-2.

3. Data Evaluation: Many of the data needed for performing the RI/FS are available for the deep aquifer, although additional data collection will be required to provide confidence in the existing information. Enough pumping tests have been conducted that collection and reinterpretation of the data should provide a good base for understanding aquifer properties. Background water quality is well documented, although the data must be used with discretion since ineffectively sealed wells may yield spurious data. Groundwater flow direction is relatively well defined.

   The vertical permeability of the deep aquitard, where present, is not known. If groundwater contamination is found to be migrating significantly downward such that it may potentially pass through the aquitard, then the vertical permeability of the aquitard would be an important characteristic to determine. Thus, aquitard permeability will be important to the RI/FS.

   Vertical components of flow in the deep aquifer are not known (MacFarlane, et al., 1981), but these are not important to the study unless subsequent investigations prove that AMD is currently passing through the aquitard. It is likely that vertical gradients could be qualitatively deduced by numerical and statistical analysis of existing data.

D. ANNOTATED BIBLIOGRAPHY OF SIGNIFICANT DATA SOURCES

Abernathy, G. E. (September 10, 1943). Deep Water Well at the Jayhawk Ordinance Works in Cherokee County, Kansas. Kansas State Geological Survey Bulletin 47, Lawrence, Kansas.

TABLE III-3

SUMMARY OF KNOWN ANALYSES OF DEEP GROUNDWATER IN CHEROKEE COUNTY, KANSAS

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
Harley No. 1 in Lamotte Ss	No		Na, Ca, Mg, SO_4, Cl, HCO_3	Abernathy (1941)
West No. 1 in Lamotte Ss	"		"	"
Girard Well in Roubidoux Fm	"	Pre-1928	Ca, Mg, Cl, Hardness, Carbonate Hardness, Non-Carbonate Hardness	"
McCune Well in Roubidoux Fm	"	"	"	"
Pittsburg Well in Roubidoux Fm	"	"	"	"
West Mineral Well in Roubidoux Fm	"	"	"	"
Galena Well in Roubidoux Fm	"	"	"	"
Clark #1 Well in Roubidoux Fm	Approx.		TDS, SO_4, Cl	"
Gable #1 Well in Roubidoux Fm	Approx.		Na, Ca, Mg, SO_4, Cl, HCO_3	
Borehole to Cotter 320' Depth	Yes	1/6/42	Fe, Ca, Mg, Na+K, HCO_3, SO_4, Cl, F, NO_3, TDS, Insoluble Residue, Alkalinity, Hardness	Abernathy (1943)

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-3 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
Borehole to Cotter 330' Depth	Yes	1/6/42	"	Abernathy (1943)
Borehole to Cotter 395' Depth	"	1/7/42	"	"
Borehole to Jefferson City 525' Depth	"	1/14/42	" (Plus Mn)	"
Borehole to Roubidoux 770' Depth	"	1/18/42	"	"
Borehole to Roubidoux Upper Dolomite 790' Depth	"	1/19/42	" (Plus Mn)	"
Borehole to Roubidoux Upper Sandstone 855' Depth	"	1/21/42	" (Plus Mn)	"
Borehole to Gasconde 890' Depth	"	1/22/42	" (Plus Mn)	"
Jayhawk Ordinance Works Well	"	2/25/42	"	"
Jayhawk Ordinance Works Well, After Acid Treatment	"	3/6/42	" (Plus Mn)	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-3 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
Cherokee City Well	Approx.	Mid-40's	Cd, Alkalinity	Williams (1948)
West Mineral Well	No	Unknown	U, Ra	Cowart (1981)
Scammon Well	"	Unknown	"	"
Cherokee Well	"	Unknown	"	"
Baxter Springs No. 1 Well	"	Unknown	"	"
Baxter Springs No. 5 Well	"	Unknown	"	"
Baxter Springs No. 6 Well	"		"	"
Well at Location 35-23E-13BAC	Yes	9/27/67	Sp. Cond., TDS, Ca, Mg, Na, K, Cl, SO_4, HCO_3, SiO_2	Spruill (1984)
Well at Location 32-25E-31AAA	"	2/26/64	" (Except Sp. Cond.)	"
USGS Sta. 371035094501301	"	7/23/81	Sp. Cond., pH, T, Ca, Mg, Na, K, Alkalinity, SO_4, Cl, F, SiO_2, TDS, NO_3, As, Ba, Cd, Cr, Fe, Pb, Mn, Se, Zn	"
USGS Sta. 370437094475501	"	7/23/81	"	"
USGS Sta. 370659094403601	"	7/31/81	"	"
USGS Sta. 370421094381301	"	7/30/81	" (Except Alkalinity)	"
USGS Sta. 371010094423201	"	7/30/81	"	"
USGS Sta. 365900094500001	"	7/23/81	"	"

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Table III-3 (continued)

Description	Map Location[1]	Sample Date	Parameters Analyzed[2]	Data Source
USGS Sta. 365600094530002	Yes	7/23/81	Sp. Cond., pH, T, Ca, Mg, Na, K, Alkalinity, SO_4, C_1, F, SiO_2, TDS, NO_3, As, Ba, Cd, Cr, Fe, Pb, Mn, Se, Zn	Spruill (1984)
USGS Sta. 370244094443001	"	7/22/81	"	"
USGS Sta. 370159094443001	"	7/23/81	"	"
USGS Sta. 370215094440301	"	7/22/81	"	"
Riverton School District 404	No	12/23/81	Ca, Mg, Na, Cl, SO_4, NO_3, F, Fe, Hardness, Alkalinity	KDHE (1984)

1 - Yes; indicates a map location for the sampling site is available.

2 - "T" indicates temperature; "TDS" indicates total dissolved solids; "TS" indicates total solids

Detailed log, water level observations, and pumping tests for a deep well advanced to the Gasconade Dolomite.

Cowart, J. B. (1981). "Uranium Isotopes and Radium-226 Content in the Deep Groundwaters of the Tri-State Region, U.S.A." Journal of Hydrology, Vol. 54, No. 185.

Samples of deep groundwater from 23 wells shows areal distribution of uranium and radium.

Hittman Assoc., Inc. (October, 1981). Draft Final Report - Surface and Groundwater Contamination from Abandoned Lead-Zinc Mines - Picher Mining District - Ottawa County, Oklahoma. Englewood, Colorado.

Based on analysis of data and costs, a combination of pumping and diversion is recommended as a remedial measure.

Kansas Department of Health and Environment (1984). Miscellaneous Well Logs and Chemical Analyses from Files. Division of Oil Field and Economic Geology, Topeka, Kansas.

Raw field data and analytical data. Not organized, and of varying quality.

Playton, S. J.; Davis, R. E.; McClafin, R. G. (1980). Chemical Quality of Water in Abandoned Zinc Mines in Northeastern Oklahoma and Southeastern Kansas. Oklahoma Geological Survey Circular 82, Norman, Oklahoma.

Stratified sampling of mine voids and statistical analysis of results.

Reed, E. W.; Schoff, S. L.; Bronson, C. C. (1955). Groundwater Resources of Ottawa County, Oklahoma. Oklahoma Geological Survey Bulletin 72, Norman, Oklahoma.

Comprehensive study of hydrogeologic properties of all strata. Includes pumping tests, well logs, water-usage data, and chemical analyses.

Spruill, T. B. (1984). Assessment of Water Resources in Lead-Zinc Mined Area in Cherokee County, Kansas and Adjacent Areas. U. S. Geological Survey Open-File Report 84-439, Denver, Colorado.

Comprehensive study of groundwater in the area, including stratigraphy, chemical distribution, groundwater flow, aquifer parameters, water levels.

Stramel, G. J. (December 15, 1957). The Hydraulic Properties of the Ordovician Rocks at Pittsburg, Kansas. Kansas State Geological Survey Bulletin 127, Part 5, Lawrence, Kansas.

Analysis of pumping tests run on a deep well.

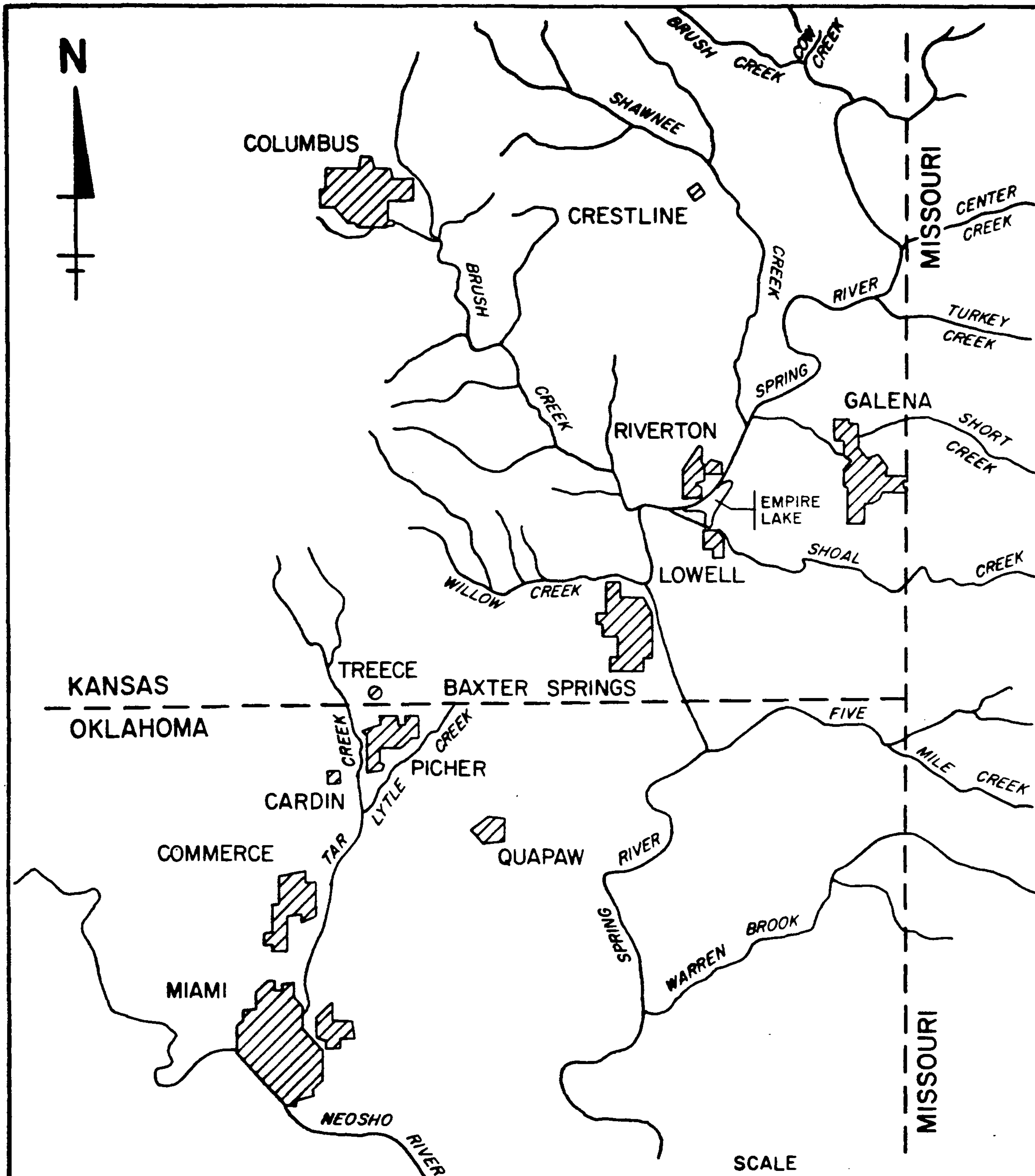
IV. SURFACE WATER RESOURCES

A. GENERAL DRAINAGE PATTERNS

There are two major drainage systems located within the boundaries of the Cherokee County, Kansas study area, as shown on Figure IV-1. The majority of the area is drained by the Spring River which flows to the south and drains the eastern portion of the study area. The Spring River flows to the west of Galena and to the east of Baxter Springs, Kansas. The Spring River is fed by its tributaries of Shoal Creek, Short Creek, Turkey Creek and Center Creek which flow to the west out of the state of Missouri. Cow Creek and Shawnee Creek enter the Spring River from the north, and Brush Creek and Willow Creek flow southeasterly and empty into the Spring River near Baxter Springs. The Spring River and Shoal Creek are impounded by dams between Lowell and Riverton to form a body of water known as Empire Lake. The dams were built to provide hydroelectric power. The Spring River continues to flow south out of Kansas and empties into the Neosho River some 16 miles south of Baxter Springs in the upper end of the Lake O' The Cherokees.

The southwest corner of the study area is drained by the headwaters of Tar Creek. Tar Creek leaves Kansas near the town of Treece and flows to the south, draining the Picher mining field of Kansas and Oklahoma. It empties into the Neosho River near the town of Miami, Oklahoma.

Due to the extensive past mining activities in Cherokee County, the surface water system has been significantly altered. While the main water courses have not changed, several of the smaller creeks have been either rerouted or even disappear into the old abandoned mine workings. In addition, numerous chat piles interrupt rainfall and delay surface runoff into the streams. Other surface water impoundments have been formed in the subsidence depressions caused by the collapse of old mine workings. During the field reconnaissance, the color of water observed in subsidence depressions and collapses varied significantly throughout the study area. The variability in water color is believed to reflect variation in water quality. These



SCALE
0 5 MILES

REFERENCE:

DRAFT REMEDIAL ACTION MASTER PLAN, CHEROKEE COUNTY, EPA, OCT. 5, 1983, FIGURE 2-1.

FIGURE IV-1

CHEROKEE COUNTY, KANSAS PORTION OF THE TRI-STATE MINING DISTRICT	SITE SURFACE HYDROLOGY
SRW ASSOCIATES INC. PITTSBURGH, PA	DATE: OCT. 26, 1984 — DR.: B. SNYDER SCALE: AS NOTED — DWG. NO.:84265-A

surface water bodies are reportedly fed by both groundwater and surface water sources.

A discussion of the available data on all of the above-mentioned surface water resources is presented in the remaining narrative of Section IV. Summaries of the known surface water sampling locations and available data are provided through a series of tables. Since the listing of parameters analyzed becomes rather lengthy at times, and the same series of parameters were analyzed for a number of sample locations, the parameters analyzed were grouped and are shown on Table IV-1. The grouping numbers listed in Table IV-1 are then used to identify the parameters analyzed on succeeding data summary tables.

B. STREAM DATA

The sampling location, period of record, number of observations, parameters analyzed, and the literature reference for the stream data reviewed are presented in Table IV-2.

C. CHAT PILE RUNOFF DATA

The sampling location, period of record, number of observations, parameters analyzed, and literature references for the chat pile runoff data reviewed are presented in Table IV-3.

D. SUBSIDENCE DEPRESSION IMPOUNDMENT DATA

The literature review did not locate any existing surface water quality data on any of the subsidence ponds located in the tri-state mining area.

E. POND AND LAKE DATA SUMMARY

The sampling locations, period of record, number of observations, parameters analyzed, and literature references for the pond and lake data reviewed are presented in Table IV-4.

TABLE IV-1

LIST OF PARAMETER GROUPINGS

Group No.	Parameters Analyzed*
1	Discharge, D.*Silica, D. Iron, D Manganese, D. Chromium, D. Copper, D. Lead, D. Zinc, D. Calcium, D. Magnesium, D. Sodium, D. Potassium, Bicarbonate, Carbonate, D. Sulfate, D. Chloride, D. Fluoride, Nitrogen, Ammonia, T.*Organic Nitrogen, D. Phosphorous, T. Phosphorous, Total Dissolved Solids, Sodium Ads. Ratio, % Sodium, Hardness, Non-Carbonate Hardness, Alkalinity, Specific Conductance, pH, Color, Temp., COD, D. Oxygen, % Saturation, Bacteriological
2	Discharge, Specific Conductance, pH, Temp., D. Oxygen, D. Calcium, D. Magnesium, D. Sodium, D. Potassium, Alkalinity, D. Sulfate, D. Chloride, D. Silica, Total Dissolved Solids, D. Arsenic, D. Barium, D. Cadmium, D. Copper, D. Iron, D. Lead, D. Manganese, D. Selenium, D. Zinc
3	Discharge, D. Silica, D. Calcium, D. Magnesium, D. Sodium, D. Potassium, Bicarbonate, D. Sulfate, D. Chloride, D. Fluoride, Total Dissolved Solids, Hardness, Non-Carbonate Hardness, Alkalinity, Specific Conductance, pH, Temp., D. Oxygen, % Saturation, Carbon Dioxide, D. Aluminum, D. Cadmium, D. Chromium, D. Cobalt, D. Copper, D. Iron, D. Lead, D. Manganese, D. Mercury, D. Nickel, D. Silver, D. Zinc, T. Zinc
4	pH, D. Oxygen, Specific Conductance, T. Cadmium, T. Chromium, T. Iron, T. Lead, T. Zinc, D. Cadmium, D. Chromium, D. Iron, D. Lead, D. Zinc
5	Specific Conductance, pH, D. Oxygen, Iron, Zinc, Cadmium, Lead, Chromium, Fluoride
6	Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Fluoride, Boron, Silica, Manganese, Copper, Lead, Zinc, Mercury, Chromium, Cadmium, Arsenic, Silver, Barium, Selenium, Pesticides, Organics, Discharge, Temp., pH, Turbidity, Specific Conductance, Total Dissolved Solids, Total Suspended Solids, Hardness, Non-Carbonate Hardness, Alkalinity, Nitrate plus Nitrite, Ammonia, Phosphorous, D. Oxygen, BOD_5, COD, Bacteriological

*D - Dissolved
T - Total
No Prefix - Unspecified

Table IV-1 (continued)

Group No.	Parameters Analyzed*
7	pH, Hardness, Sodium, Alkalinity, Chloride, Sulfate, Nitrate, Fluoride, Phosphate, Lead, Zinc, Cadmium
8	pH, Total Dissolved Solids, Ammonia, Sulfate, Nitrate, Phosphate, Fluoride, Iron, Lead, Copper, Chromium, Cadmium, Aluminum, Zinc, Hardness
9	pH, Alkalinity, Specific Conductance, Nitrate, Phosphate, Sulfate, Chloride, D. Oxygen, Temp., Turbidity
10	Discharge, Specific Conductance, pH, Temp., Turbidity, D. Oxygen, COD, D. Calcium, D. Magnesium, D. Sodium, D. Potassium, Bicarbonate, Carbonate, D. Sulfate, D. Chloride, D. Fluoride, D. Silica, Ammonia, Phosphorous, Suspended Sediment, Total Dissolved Solids, Acidity

*D - Dissolved
T - Total
No Prefix - Unspecified

TABLE IV-2

STREAM DATA SUMMARY

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Spring River near Waco, MO	Yes	April, 1924 to Present	Daily	Discharge	USGS-MO(1975)	Raw Data
"	Yes	Nov., 1965 to July, 1975 (Discontinued)	Bi-Monthly	Group 1	"	"
"	Yes	Nov., 1965 to Present	Monthly	Group 6	KDHE (1983)	"
"	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling
"	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Spring River near Crestline, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Spring River near Badger, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Spring River near Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Center Creek near Smithfield, MO	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
"	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling
Turkey Creek near Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Tributary No. 1 to Short Creek	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

Table IV-2 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Short Creek near Central City, MO	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Short Creek East of Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Spring Branch near Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Tributary No. 2 to Short Creek	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Triburary No. 3 to Short Creek	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Tributary No. 4 to Short Creek	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Short Creek at Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Tributary No. 5 to Short Creek	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Short Creek West of Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Spring River Tributary Near Galena, KS	Yes	8/11/82	One Time	Group 2	Spriull (1984)	"
Willow Creek Tributary Near Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Brewster Ditch near Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

Table IV-2 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Willow Creek at Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Willow Creek 1 Mile West of Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Willow Creek 2 Miles West of Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Willow Creek 3 Miles West of Baxter Springs, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	"
Tar Creek at Treece, KS	Yes	8/13/81, 3/18/82	Two	Group 2	Spruill (1984)	"
Tar Creek 1 Mile Northwest of Treece, KS	Yes	8/13/81	One Time	Group 2	Spruill (1984)	"
Tar Creek near Cravensville, KS	Yes	6/17/81	One Time	Group 2	Spruill (1984)	"
Shoal Creek near Galena, KS	Yes	10/68 to 7/75 (discontinued)	Monthly	Group 1 Except for D.Cr, D.Cu, D.Pb and D.Zn	USGS-MO (1975)	Raw Data
"	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

Table IV-2 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Center Creek near Carter-ville, MO	Yes	June, 1962 to Present	Daily	Discharge	USGS-MO (1975)	Raw Data
"	Yes	Aug., 1962 to 9/75, Discontinued	Bi-Weekly	Group 1	USGS-MO (1975)	Raw Data
"	Yes	10/75-9/75	Daily Maximum and Minimum	Sp.Cond., pH, D.O., Temp.	USGS-MO (1975)	"
Center Creek near Carter-ville, MO	Yes	1979	Monthly	Group 2	Spruill (1984)	USGS Study
Shoal Creek Above Joplin, MO	Yes	10/41 to Present	Daily	Discharge	USGS-MO (1975)	Raw Data
Short Creek at KS-MO Line		3/10/76 6/23/76 9/21/76	3	Group 3	Barks (1977)	Missouri Study
Turkey Creek near Joplin, MO	Yes	3/10/76 6/23/76 9/21/76	3	Group 3	"	"
"	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling
Tar Creek at KS-OK Border	Yes	6/4/82 to 12/27/82	17	Group 5	OWRB (1983)	Superfund Investigation
Spring River East of Miami, OK	Yes	6/4/82 to 12/27/82	17	Group 5	OWRB (1983)	"
Shoal Creek at KS-MO Border	Yes	July, 1967 to Present	Monthly	Group 6	KDHE (1983)	Raw Data
Spring River near Baxter Springs, KS	Yes	Oct., 1961 to Present	Monthly	Group 6	"	"

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

Table IV-2 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Cow Creek near Weir, KS	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling
Brusk Creek near Weir, KS	Yes	"	Unknown	Group 8	KDHE (1980)	"
Spring River at K-96 Bridge, KS	Yes	"	Unknown	Group 8	KDHE (1980)	"
Spring River Above Gulf Chemical, KS	Yes	"	Unknown	Group 8	"	"
Spring River Above Short Creek, KS	Yes	"	Unknown	Group 8	"	"
Short Creek Near Galena, KS	Yes	Fall, 1978 to Spring, 1979	Unknown	Group 8	KDHE (1980)	Study Objectives-Biological Sampling
Brush Creek Near Riverton, KS	Yes	"	Unknown	Group 8	"	"
Spring River Below Riverton Impoundment, KS	Yes	"	Unknown	Group 8	"	"
Willow Creek Near Baxter Springs, KS	Yes	"	Unknown	Group 8	"	"
Spring River Near Baxter Springs, KS	Yes	"	Unknown	Group 8	"	"
Spring River Near Quapaw, OK	Yes	"	Unknown	Group 8	"	"
Willow Creek North of Baxter Springs, KS	Yes	1977	Random/9-16	Group 10	KDHE (1978)	Main Study Objective-Coal Mine Drainage

[1] - Sample number provided to indicate that an approximate map location for each site is available.

[2] - Group numbers refer to those defined in Table IV-1.

Table IV-2 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Shoal Creek South of Galena, KS	Yes	1977	Random/9-16	Group 10	"	"
Short Creek at Galena, KS	Yes	1977	Random/9-16	Group 10	"	"
Tar Creek at KS-OK Border	Yes	1977	Random/9-16	Group 10	"	"
Brush Creek North of Baxter Springs, KS	Yes	7/15/75	1	Group 9	KS Fish and Game Comm. (1980)	Stream Survey
Shawnee Creek Above Highway 69 Bridge, KS	Yes	6/27/78	1	Group 9	"	"
Cow Creek West of Lawton, KS		7/23/75	1	Group 9	"	"

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

TABLE IV-3

CHAT PILE RUNOFF DATA SUMMARY

Location/ Description	Map Location	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Chat Seepage No. 1 Near Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Chat Seepage No. 2 Near Galena, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Chat Seepage No. 3 Near Treece, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
North of Confluence of Tar and Lytle Creeks, OK	Yes	11/29-82 to 12/3/82	5	Group 4	OWRB (1983)	Superfund Investigation
From Pioneer Chat Pile (Largest) South of KS-OK Border	Yes	11/29/82 to 12/3/82	5	Group 4	OWRB (1983)	Superfund Investigation

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

TABLE IV-4

POND AND LAKE DATA SUMMARY

Location/ Description	Map Location	Period of Record	No. of Observations	Parameters[2]	Reference	Comments
Empire Lake 4 Miles Northeast of Riverton, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Empire Lake at Riverton, KS	Yes	8/11/82	One Time	Group 2	Spruill (1984)	USGS Study
Bennetts North Pond, KS	Yes	3/24/71	One Time	Group 7	Irwin (1971)	During Active Smelting
Bennetts South Pond, KS	Yes	3/24/71	One Time	Group 7	Irwin (1971)	During Smelting
Mallatts North Pond, KS	Yes	3/24/71	One Time	Group 7	Irwin (1971)	During Smelting
Woods North Pond, KS	Yes	3/24/71	One Time	Group 7	Irwin (1971)	During Smelting
E. Fields North Pond, KS	Yes	3/24/71	One Time	Group 7	Irwin (1971)	During Smelting

1 - Sample number provided to indicate that an approximate map location for each site is available.

2 - Group numbers refer to those defined in Table IV-1.

F. DATA EVALUATION

The compilation of Tables IV-2, 3 and 4 listed a large number of surface water sample locations which were identified during the literature search and review task for this study. A large number of sample locations were expected based on the known volume of previously performed studies and reports that were identified in the RAMP preparation. Upon review of the known available data, it became evident that a large number of sample locations did not directly translate into a large amount of useable data for a remedial investigation. An evaluation of the available data reviewed led to the following observations and conclusions.

Of the 65 sample stations identified, 13 of them are either in Missouri or Oklahoma, or on the Kansas-Missouri or Kansas-Oklahoma border. This data is of little value in addressing any potential site specific water quality problems later identified in Cherokee County, Kansas. These data were obtained from USGS-MO (1975); Barks (1977); and OWRB (1983).

The main reference in terms of identifying and summarizing Cherokee County, Kansas sample locations was the USGS report by Spruill (1984). In reviewing his data, it must be noted that data from these sample locations were one-time samples. In fact, of the 52 Kansas sampling locations, a total of 35 (or 67%) are one-time samples. These samples were collected for a particular study to provide general information for a large area. Consequently, the data are valuable for estimating general overall water quality at the time of sampling and can be useful as a screening tool for identifying locations where additional sampling is required. With one-time sampling data, it is difficult to identify any seasonal trends in water quality or to provide a data base to be used to engineer and develop remedial abatement programs. A comprehensive data base sufficient to identify specific locations and trends in contamination of a surface water resource was not the goal of any of these studies. A partial retrieval of some available STORET data also identified numerous one-time sampling programs.

In the literature review, it was discovered that a total of 307 surface collapses (McCauley, et al., 1983) were identified during a Bureau of Mines hazard survey of the Kansas lead/zinc mining area. A large number of these are reported to contain pools of water. During the site visit, water within surface collapses was observed to vary in color, presumably reflective of differences in water quality. However, the literature review did not identify that any of these subsidence ponds had been sampled. The total amount of information obtained for surface water bodies consisted of only two locations from Empire Lake and five locations from ponds north of Galena, Kansas near the old Picher mining smelter. These were all also one-time samples.

Due to some degree of uncertainty caused by the small scale mapping available to locate these sample locations, it is possible that a number of these locations may be duplicates. For instance, several locations near Shoal Creek, Kansas may or may not identify the same sampling station. Due to this uncertainty, the actual number of sample locations may be less, and correlation between water quality characteristics may prove difficult.

The initial site visit identified numerous chat piles and associated surface disturbance areas. McCauley, et al. (1983) identified a total of 2,328 acres covered by mining wastes. However, the literature review identified surface water runoff data for only three chat piles in Kansas, one near Treece and two near Galena. Literature from Oklahoma (OWRB, 1983, Task I.2) and Missouri (Barks, 1977) identified leachate and runoff from chat piles as a source of dissolved metals, yet very little data is available to document and assess the severity of this problem in Kansas.

A key to the value of any water quality data is the development of the sampling program to suit the intended use. It appears that none of the existing data were meant to be used as a qualified data base to support a RI/FS, and therefore may not be suitable as such for that particular purpose. Data are available from six or seven routine USGS stations; however, these stations are a significant distance from each other. The data from these stations are useful in making general conclusions if there is a contamination problem in a particular stream. They are not useful, however, in trying to identify the specific source of the contamination problem.

Another limitation in the data is the selection of parameters analyzed. The majority of the studies were analyzed for dissolved constituents only, while others were analyzed for total concentrations. Without both values, it is difficult to estimate the stage of contamination or to identify any trend in quality as to whether the stream is continuing to degrade or is assimilating some of the contamination problems. It was noted that the selection of parameters for the Oklahoma Superfund study (OWRB, 1983) was limited to a number of key indicator parameters analyzed for both total and dissolved metals. A similar sampling program would benefit the analysis at the Cherokee County, Kansas site.

G. ANNOTATED BIBLIOGRAPHY FOR SIGNIFICANT DATA REFERENCES

This section lists the most important data references identified that contain significant data pertaining to Cherokee County, Kansas.

Kansas Fish and Game Commission (May, 1980). Neosho River Basin, Kansas Stream Survey, Pratt, Kansas.

> Provides a general physical, chemical, and biological survey of streams within the Neosho River Basin in Kansas.

Irwin, John C. (1971). Survey of Environmental Contaminants Near Galena, Kansas, Air Quality and Occupational Health Section, Kansas Department of Health, Topeka, Kansas.

> Provides results and interpretation of air, soil, and water samples obtained in response to reports of livestock sickness in the area downwind of the Galena (Eagle-Picher) smelter during operation.

Spruill, Timothy B. (1981). Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas, and Adjacent Areas, USGS OFR 84-439, Lawrence, Kansas.

Provides comprehensive summary of water resources in mined areas of Cherokee County, Kansas. Includes data on water quality characteristics of groundwater and surface water. Author attempts to define the type and extent of chemical pollution and provides a description of the hydrology and geochemistry of the study area.

Kansas Department of Health and Environment (January, 1978), Kansas Water Quality Management Plan, Water Quality Management Section, Topeka, KS.

Addresses mining resources and water quality in the Cow Creek Basin. This is a coal mining region in northern Cherokee County that empties into the Spring River. The stream sampling sites are those of the USGS. Water quality serves only as a background quality in 1977 indicative of coal mine drainage influences prior to entering the lead-zinc mining area of Cherokee County currently being investigated.

Kansas Department of Health and Environment (December, 1980). Water Quality Investigations of Lead-Zinc Mine Drainage Effect on Spring River and Associated Tributaries in Kansas, 1978-1979, Water Quality Management Section, Topeka, Kansas.

Report provides chemical and biological data for several streams in the mined area of Cherokee County, Kansas. The physical, hydrologic, chemical, and biological characteristics of each stream is presented, then the authors present their interpretation of data.

Kansas Department of Health and Environment (1984). Water Quality Data for Kansas, Water Year 1983, Water Quality Management Section, Topeka, Kansas.

Provides raw data for water year 1983 for Kansas stations. Single volume of an annual report series of sampling of streams and lakes begun by KDHE in 1962.

USGS (August, 1976). Water Resources Data for Missouri, Water Year 1975, USGS Water-Data Report MO-75-1, Rolla, Missouri.

Provides raw data for water year 1975 for Missouri stations. Single volume of an annual report series of stage, discharge, and water quality of streams; and stage, and water quality of lakes and reservoirs begun by USGS in 1964 on a state-by-state basis.

V. AIR QUALITY

A. BACKGROUND

Current potential sources of atmospheric loading associated with abandoned lead and zinc mining activity in the Cherokee County area may involve fugitive dust emissions from chat piles, tailings ponds, and the reuse of chat in construction. The last industrial point source associated with ore smelting was discontinued about September, 1971 with the shut-down of the last operational smelter at Galena, Kansas (Lagerwerff and Brower, 1974). The historical record of specific metal smelting operations that occurred at Galena is inconsistent among references. It is possible that air emissions may have changed as different metals were produced. Chat piles and tailings ponds are potential sources of fugitive dust through wind erosion. Reworking or removal of chat piles may produce fugitive dusts if improper dust suppression methods are used. Reuse of chat is common in the study area and may result in fugitive dust emissions through wind or vehicular action from unimproved road surfaces, driveways, parking areas, railway road beds, and other construction uses. Pedco (1981) indicated that 113 major exposed chat areas, two tailings ponds, and 198.11 miles of unimproved roads and railroad beds were present in Cherokee County, based on aerial photo interpretation covering 68% of the County.

B. AIR QUALITY DATA

Information pertaining to the study area were obtained from reports, publications, and personal visits. The information on data available is summarized in Table V-1. Additional information is available on industrial point sources through the EPA's Compliance Data Systems (CDS) and the National Emissions Data System (NEDS). The most recent inventory was performed in 1983, but has not yet been submitted to EPA for entry into the data system. This information can be used to assess potential influences of known emission sources during the sample collection periods. An evaluation of existing industrial point emission source locations and sampling data availability was not performed as part of this report.

TABLE V-1
AIR QUALITY DATA SOURCE SUMMARY

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Constituents[2]	Reference	Comments
Bennett Farm Galena, KS	Yes	3/26-4/30/71	30	TSP, Pb, Cd, Settleable Particulate	Irwin (1971)	Downwind of Active Smelter
		3/26-4/30/71	1	Sulfation Rate	Irwin (1971)	"
Woods Farm Galena, KS	Yes	3/26-4/30/71	33	TSP, Pb, Cd, Settleable Particulate	Irwin (1971)	"
		3/26-4/30/71	1	Sulfation Rate	Irwin (1971)	"
Mallatt Farm Galena, KS	Yes	3/26-4/30/71	34	TSP, Pb, Cd	Irwin (1971)	"
L. Fields Residence Galena, KS	Yes	4/12-4/29/71	18	Sulfur Dioxide	Irwin (1971)	"
Near Galena Smelter	Yes	1970	6	TSP	Lagerwerff & Brower (1975)	KDHE Data by M. Gray Smelter Active
Near Galena Smelter	Yes	1970	2	TSP	"	KDHE Data by B.L. Glendenning Smelter Active
Galena, KS	Yes	1973 (106 days)	2	Settleable Particulate, Fe, Al, Dc, Pb, Zn	"	Smelter Closed

1 Yes - Indicates a map location for the sampling site is available.

2 TSP - Total Suspended Particulates, IP - Inhalable Particulates (size less than 15 micron.)

Table V-1 (continued)

Location/ Description	Map Location[1]	Period of Record	No. of Observations	Constituents[2]	Reference	Comments
Galena, KS	Yes	1973 (255 days)	4	Settleable Particulate, Cd, Pb, Zn	"	"
Galena, KS	Yes	1972-1976	152	TSP	USEPA-RAMP (1983)	
Galena, KS	Yes	5/6-5/30/75	5	TSP analyzed for Cu, Cr, Co, Fe, Mn, Ni, Pb	"	
West of Treece, KS	Yes	7/17-11/26/83	15	TSP, IP, Fe, Mn Cu, Pb, Ag, Co, Zn, Cd, Cr, Ni, Be, Ba, As	KDHE (1984)	Raw Data
Treece, KS	Yes	7/17-11/26/83	21	"	"	"
Baxter Springs, KS	Yes	7/17-11/26/83	23	TSP, Fe, Mn, Cu, Pb, Ag, Co, Zn, Cd, Cr, Ni, Be, Ba, As	"	"
South of Galena, KS	Yes	7/17-11/26/83	20	"	"	"
Galena, KS	Yes	7/23-11/26/83	15	"	"	"
Columbus, KS	Yes	7/17-11/26/83	22	"	"	"

1 Yes - Indicates a map location for the sampling site is available.

2 TSP - Total Suspended Particulates, IP - Inhalable Particulates (size less than 15 micron.)

C. DATA EVALUATION

Table V-1 indicates the majority of air quality data has been obtained in the vicinity of Galena, Kansas. Approximately one-third of the data collected was obtained during active smelter operations in Galena and reflect historical air quality conditions. Only the most recent data obtained during July through November, 1983 at other locations provide information on recent ambient air quality near the major population centers within the study area. These data were collected and analyzed by the Kansas Department of Health and Environment. These data were evaluated as being of good overall quality and useful in assessing general ambient air quality near the sampled areas. Additional characteristics, including gross alpha, gross beta, radium 226, and fibrous materials have been suggested by Neuberger et al. (1983) as possible environmental contaminants in the area. However, no data was obtained during this literature review which addresses these concerns.

No data are available for assessing the impacts of specific area sources (i.e. chat piles or tailings ponds) on local air quality near potential receptors. In addition, no data are available for use in evaluating potential human exposure during vehicular use of chat-covered unimproved roads or on local air quality adjacent to chat-covered unimproved roads.

D. ANNOTATED BIBLIOGRAPHY FOR SIGNIFICANT DATA REFERENCES

Irwin, John C. (1971). Survey of Environmental Contaminants Near Galena, Kansas: Air Quality and Occupational Health Section, Kansas Department of Health, 63 p.

> Provides results and interpretation of air, soil, and water samples obtained in response to reports of livestock sickness in the area downwind of the Galena (Eagle-Picher) smelter during operation.

Kansas Department of Health and Environment (1984). Preliminary Air Sampling Data (unpublished) Obtained from John C. Irwin, Chief Environmental

Toxicology Section, Bureau of Air Quality and Radiation Control.

Raw data only. No report prepared as of October 23, 1984.

Lagerwerff, J. V. and D. L. Brower (1975). Source Determination of Heavy Metal Contaminants in the Soil of a Mine and Smelter Area: In: Trace Substances in Environmental Health - IX, D. D. Hemphill, Ed., University of Missouri, Columbia, pp 207-215.

Provides an example using data collected near Galena, Kansas of methods for distinguishing between different contamination sources of soils and plants with Cd, Pb and Zn where several sources co-exist.

VI. SOIL DATA

A. GENERAL

Data types addressed in this section include natural undisturbed soils, soils disturbed by farming operations, chat piles, and tailings (slurry) ponds. A published soil survey is not available for Cherokee County; however, soil series data was obtained from the USDA Cherokee County office from the preliminary soil survey (Pat Broyles, personal communication 10/23/84).

In the Galena area, lowland soils consist of Cherokee, Dennis, Vertigree, and Lanton silt loams. These soil types have been formed in many areas, resulting in chemical variability due to different soil management practices. The hillside soils near Galena include the Nixa and Clarksville cherty loams which have soil pH values ranging from 5.0 to 6.0. In the Baxter Springs/Treece area, the major soil types consist of the Dennis and Parsons silt loams. In farmed areas, the chemical characteristics of these groups may also be variable due to different soil management practices.

McCauley et al. (1983) reported that approximately 2,328 acres of Cherokee County, Kansas were covered with mining wastes located in over 104 documented chat piles and tailings ponds. Chemical constituents remaining in the chat piles are believed to vary between piles as a result of ore reprocessing for secondary removal of metal. During the site visit, it was observed that chat piles and tailings ponds were essentially unvegetated. No information was available in the literature to assess whether a physical or chemical constraint prohibits the establishment of vegetation or whether repeated disturbances from previous chat pile reprocessing have prevented the growth of vegetation.

B. SOIL QUALITY DATA

Information obtained from reports, publications, personal visits, and phone interviews are summarized in Table VI. It is possible that additional

TABLE VI

SOIL DATA SOURCE SUMMARY

Location/ Description	Map Location	Date	No. of Observations	Constitutents	Reference	Comments
Galena, KS	Yes	1971	6 Profiles	Pb, Zn, Cd	Irwin (1971)	Downwind of Active Smelte
Galena, KS	Yes	1972	3 Profiles	Cd,Cu,Pb,Zn,pH	Langerwerff *et al.* (1972)	"
Galena, KS	Yes	1972	3 Profiles 3 Profiles	Cd,Cu,Pb,Zn,pH,Mn "	" "	" Downwind (Protected) from Smelter Influence
Tailings Pond Baxter Springs	Yes	1983	1 Composite	Fe,Mn,As,Ba,Cd,Cr, Cu,Pb,Se,Ag,Zn,Al, Ni,Co	KDHE (1983)	Raw Data
Tailings Pond Baxter Springs	Yes	1983	1 Composite	"	"	"
Tailings Pond Treece	Yes	1983	1 Composite	"	"	"
Tailings Pond Treece	Yes	1983	1 Composite	"	"	"
Tailings Pond Treece	Yes	1983	1 Composite	"	"	"
Woodland Soil Treece	Yes	1983	1 Composite	"	"	"
Tailings Pile Galena	Yes	1983	1 Composite	"	"	"
Tailings Pile Galena	Yes	1983	1 Composite	"	"	"

[1] Yes - Indicates a map location for the sampling site is available.

information is available from sources not able to be contacted due to the schedule required for the production of this report.

C. DATA EVALUATION

Examination of Table VI indicates that very little data are available on the chemical characteristics of native soils within the study area. Native soils may be a source of contamination if the parent material contained natural high concentrations of contaminants, or if the soil was subject to historical mining-related contamination. These data would be valuable in evaluating the chemical variability in background levels of chemical constituents and establishing a basis for assessing potential contamination.

Both the Irwin (1971) and Lagerwerff et al. (1972) data were obtained in the downwind areas of the Galena smelter and are representative of only that particular area.

No useable data was obtained indicating the grain size or particle size distribution and variability of chat pile and tailings pond material. This information would be useful in evaluating the wind and water erosional susceptibility of the material which may influence air quality and water quality.

Very limited data (Lagerwerff et al., 1972) is available on the vertical variability of chemical characteristics in native soil profiles. In addition, no data was obtained on the chemical variability (horizontally and vertically) in chat piles or tailings ponds. Based on documented chat pile and tailings pond figures presented in McCauley (1983), less than 7% of chat piles and tailings ponds have been sampled for analysis of heavy metal constituents.

No data is available to establish the comparative concentrations of leachable to total extractable metals in either soils or chat wastes. This information can be useful in evaluating long-term release of chemicals from the material. In addition, no data is available on the agricultural characteristics of chat and tailings pond material for use in assessing revegetation potential.

Additional characteristics, including gross alpha, gross beta, radium 226 and fibrous materials have been suggested by Neuberger et al. (1983) as possible environmental contaminants in the area. However, no data was obtained during this literature review which addresses these concerns.

Recent (1983) data obtained by KDHE are of good quality; however, these were obtained as environmental samples and were not subject to quality assurance/quality control procedures at a level equivalent to current Superfund requirements. The 1971 and 1972 sampling reported in Table VI is estimated to be of somewhat lower quality than the 1983 data due to improvements in analytical methods from 1971 to 1983.

Based on the preceding discussion, it is our opinion that insufficient data is available to assess general soil/chat conditions or for use in identifying specific problem areas which may influence environmental quality in the Cherokee County area.

D. ANNOTATED BIBLIOGRAPHY FOR SIGNIFICANT DATA REFERENCES

Irwin, John C. (1971). Survey of Environmental Contaminants Near Galena, Kansas: Air Quality and Occupational Health Section, Kansas Department of Health, 63 p.

Provides results and interpretation of air, soil, and water samples obtained in response to reports of livestock sickness in the area downwind of the Galena (Eagle-Picher) smelter during operation.

Kansas Department of Health and Environment (1984). Preliminary Air Sampling Data (unpublished) Obtained from John C. Irwin, Chief Environmental Toxicology Section, Bureau of Air Quality and Radiation Control.

Raw data only. No report prepared as of October 23, 1984.

Lagerwerff, J. V., D. L. Brower, and G. T. Biersdorf (1972). Accumulation of Cadmium, Copper, Lead and Zinc in Soil and Vegetation in the Proximity of a Smelter: In: Trace Substances in Environmental Health - VI, D. D. Hemphill, Ed., University of Missouri, Columbia, pp 71-78.

Provides results and interpretation of soil and plant samples obtained in the area downwind of the Galena (Eagle-Picher) smelter.

VII. SEDIMENT DATA

A. GENERAL CONCERNS

The deposition of sediment in lakes and stream bottoms can occur due to several modes of transport. The most obvious of these is direct transport of suspended particles by water. The majority of suspended sediment carried to streams and lakes occurs following major precipitation events, although base flow conditions can result in some cumulative sedimentation problems.

In the lead-zinc mining area of Cherokee County, potential sources of suspended sediment include chat piles and tailings ponds. Tailings ponds contain predominantly more finer grained material than chat piles, and may be more susceptible to erosion.

Another method of sedimentation is the transport of dissolved chemical constituents in the acidic mineralized mine water entering the streams in Cherokee County. A subsequent raise in pH in the receiving stream results in the release of these minerals from solution by the formation of precipitates. These precipitates contribute to form a layer of sediment buildup along stream bottoms.

A third possible method of sedimentation would be the air-borne transport of fine material from chat piles and tailings ponds to an adjacent surface water system. It is not known if this is a significant contaminant transport pathway.

B. SEDIMENT QUALITY DATA

The literature search and review task identified only one sediment sample location for which data was available. The lone set of data was obtained during the Tar Creek Superfund investigation at a point on Tar Creek at the Kansas-Oklahoma border (OWRB, 1983). A total of three samples were taken in June, July, and September, 1982 to develop a profile of heavy metals in sediments in Tar Creek.

C. DATA EVALUATION

There were no data for Kansas streams and lakes, on either extent of sedimentation or chemical quality of sediments, identified during the literature search and review.

VIII. BIOLOGICAL DATA

A. GENERAL CONCERNS

Past lead and zinc mining activity in the Cherokee County area may potentially affect aquatic and terrestrial life through contamination of surface water, ground water, soil or air. These effects may be manifest by changes in the chemical environment through contamination of environmental media, by changes in physical environment through erosion and deposition of sediment, or by other changes in ecological interrelationships.

During active mining, many of the streams in the study area received groundwater pumped from the mines for dewatering or used in ore cleaning operations. At other locations, stream channels were relocated or subject to encroachment by chat piles. In most cases, these effects, which may affect interpretation of aquatic biological data, have not been documented over time.

B. BIOLOGICAL DATA

Table VIII-1 summarizes the data obtained dealing with aquatic biology sampling in the Cherokee County area. Locations indicated with a (1) in Table VIII-1 are sites of USGS water quality sampling locations. Various sampling methods were used to obtain the data summarized in Table VIII-1. Electroshocking or seining was reported to be used in obtaining fish samples during the Kansas Fish and Game Commission (KFGC, 1980) survey. The KFGC (1980) report does not indicate specific methods used to collect samples at the locations cited. Benthic invertebrate data in Table VIII-1 reported by the Kansas Department of Health and Environment (1980 and 1984) and collected during and after 1978 was obtained using a semi-quantitative method involving sampling with a D-net for one man/hour. Prior to 1978, various methods of sampling were used.

Table VIII-2 summarizes data obtained on vegetation samples and home produce obtained from downwind locations during operation of the smelter at Galena,

TABLE VIII-1

AQUATIC BIOLOGICAL DATA SOURCE SUMMARY

Location	Description	Map Location[2]	Period of Record	No. of Observations	Data Type	Reference
Brush Creek	3.5 miles north of Baxter Springs, KS	Yes	7/15/75	1	Physical/Chemical/Fish	KFGC (1980)
Brush Creek	Near Riverton, KS	Yes	Spring, 1979	1	Benthic Invertebrates	KDHE (1980)
Center Creek[1]	Near Springfield, MO	Yes	1978, 1979	1	Benthic Invertebrates	KDHE (1980)
Cow Creek	1 mile west of Lawton, KS	Yes	7/23/75	1	Physical/Chemical/Fish	KFGC (1980)
Cow Creek	8 miles above confluence with Spring River	Yes	1979	1	Benthic Invertebrates	KDHE (1980)
Shawnee Creek	North of Crestline, KS	Yes	6/27/78	1	Physical/Chemical/Fish	KFGC (1980)
Shoal Creek	Near Galena, KS	Yes	1982-1984	3	Benthic Invertebrates	KDHE (1984)
Shoal Creek	Near Galena, KS	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Short Creek	Near Galena, KS	Yes	1979	1	Benthic Invertebrates	KDHE (1980)
Short Creek[1]	Near Galena, KS	Yes	1976-1979	3	Benthic Invertebrates	KDHE (1984)
Spring River	Near Waco, MO	Yes	1978-1979	2	Benthic Invertebrates	KDHE (1980)
Spring River[1]	Near Waco, MO	Yes	1973 to 1974	13	Benthic Invertebrates	KDHE (1984)
Spring River	At K-96 Bridge	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River	Above Gulf Chemical Co.	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River	Above Short Creek	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River	Below Riverton Impoundment	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River	Near Baxter Springs, KS	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River	Near Baxter Springs, KS	Yes	1972, 1984	12	Benthic Invertebrates	KDHE (1984)

1 - Indicates the sampling location is at the site of a USGS water quality sampling location.

2 - Yes, Indicates a map location for the sampling site is available.

Table VIII-1 (continued)

Location	Description	Map Location[2]	Period of Record	No. of Observations	Data Type	Reference
Spring River	Near Quapaw, OK	Yes	1978, 1979	2	Benthic Invertebrates	KDHE (1980)
Spring River[1]	Near Quapaw, OK	Yes	1972 to 1979	3	Benthic Invertebrates	KDHE (1984)
Turkey Creek[1]	Near Joplin, MO	Yes	1978, 1979	2	Benthic Invertebrate	KDHE (1980)
Willow Creek	Near Baxter Springs, KS	Yes	1978, 1979	2	Benthic Invertebrate	KDHE (1980)

1 - Indicates the sampling location is at the site of a USGS water quality sampling location.

2 - Yes, Indicates a map location for the sampling site is available.

TABLE VIII-2

VEGETATION/HOME PRODUCE DATA SOURCE SUMMARY

Location	Description	Map Location2	Period of Record	No. of Observations	Data Type	Reference
Bennett's North Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
Bennett's Southcentral Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
Bennett's Southwest Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
Mallatt's North Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
Wood's North Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
L. Fields South Pasture Grass Galena, KS	Downwind Active Smelter	Yes	1971	4	Surface/Total Pb, Zn, Cd	Irwin (1971)
Bennett's Hay Galena, KS	Downwind Active Smelter	No	1971	1	Surface/Total Pb, Zn, Cd	Irwin (1971)
Baxter Springs Hay Galena, KS	Downwind Active Smelter	No	1971	1	Surface/Total Pb,	Irwin (1971)
Galena, KS Grass	Downwind Active Smelter	Yes	Aug., 1971	9	Total Cd, Cu, Pb, Zn	Lagerwerff, et al. (1972)

2 – Yes, Indicates a map location for the sampling site is available

Table VIII-2 (continued)

Location	Description	Map Location[2]	Period of Record	No. of Observations	Data Type	Reference
Spring Milk Galena, KS	Spring Milk Following Smelter Closure	No	May, 1972	10	Total Cd, Pb, Zn	Lagerwerff and Brower (1974)
Winter Milk Galena, KS	Winter Milk Following Smelter Closure	No	Jan., 1973	6	Total Cd, Pb, Zn	Legerwerff and Brower (1974)
Home Grown Produce Galena, KS	Samples Reported by Grower to be Frozen Prior to Smelter Closure	No	Prior 9/71	44	Total Cd, Pb, Zn	Lagerwerff and Brower (1974)

2 - Yes, Indicates a map location for the sampling site is available

Kansas. The only reference to vegetation stress was by Ecology and Environment (1982) who reported an area of stressed vegetation downwind of the Galena, Kansas smelter.

C. DATA EVALUATION

The benthic invertebrate and fisheries sampling points were located for the purpose of providing a general survey system for assessment of stream habitat in the Spring River area of Kansas. For this reason, the sampling locations were widely spaced and were not specifically located to assess site specific or local effects of lead and zinc mining disturbances. No aquatic survey information was obtained during the literature survey for the Empire Lake area near Riverton, Kansas, or the streams in the vicinity of Treece, Lawton and Badger, Kansas. No information was obtained to assess potential accumulation of heavy metals in sport fish tissue in Cherokee County streams.

The references (KDHE 1980, 1984; FKGC 1980) providing aquatic biology information were summary documents and did not present complete raw data for the samples obtained. The specific sampling methods used to collect benthic invertebrate and fisheries samples at each location were not well documented in the reports. Data were summarized using percent of total sample by number and weight for fish species and by number of total taxa and tolerance of individual taxa to decomposible organic wastes for benthic invertebrates.

As a general evaluation, the existing aquatic biological information is of value in characterizing the general degree of induced stress on the benthic invertebrate community in Cherokee County, and can be of use as a screening tool in identifying locations where additional sampling is required. However, neither the benthic invertebrate or fisheries sampling locations were established to assess site-specific effects from the lead and zinc mined areas. The data, therefore, are of limited value in assessing site specific conditions required for a remedial investigation.

The data presented in Table VIII-2 were primarily obtained near Galena, Kansas downwind of the ore smelter and reflects direct or residual effects of the air emissions from the smelter. The methods used in collecting and analyzing the chemical constituents vary between authors and may not be directly comparable. No information was obtained during the literature survey which could be used to evaluate background heavy metal concentrations or to assess the potential for bioaccumulation of heavy metals in agricultural or forage crops grown adjacent to mining wastes or bioaccumulation in vegetation growing on mining waste piles.

D. ANNOTATED BIBLIOGRAPHY FOR SIGNIFICANT DATA REFERENCES

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> Provides results and interpretation of air, soil, and water samples obtained in response to reports of livestock sickness in the area downwind of the Galena (Eagle-Picher) smelter during operation.

Kansas Department of Health and Environment (1980). Water Quality Investigations of Lead-Zinc Mine Drainage Effects on Spring River and Associated Tributaries in Kansas, 1978-1979,

> Provides benthic invertebrate and water quality data summaries and conclusions for 15 stations in the Spring River watershed.

Kansas Department of Health and Environment (1984). Summary of Active Biological Sampling Stations (unpublished). Obtained from Donald Snethen, Chief, Water Quality Assessment Section.

> Provides station location, period of record, and number of samples obtained from Kansas Biological Ambient Network stations in Cherokee County, Kansas.

Kansas Fish and Game Commission (1980). Neosho River Basin, Kansas Stream Survey, 163 p.

Summary of fishers, chemical and physical stream data for three locations in Cherokee County, Kansas.

Lagerwerff, J. V., D. L. Brower, and G. T. Biersdorf (1974). Accumulation of Cadmium, Copper, Lead and Zinc in Soil and Vegetation in the Proximity of a Smelter: In: Trace Substances in Environmental Health - VI, D. D. Hemphill, Ed., University of Missouri, Columbia, pp. 71-77.

Provides data and interpretation of analytical results of soil and plant samples obtained near the Eagle-Picher smelter at Galena, Kansas.

Lagerwerff, J. V. and D. L. Brower (1975). Source Determination of Heavy Metal Contaminants in the Soil of a Mine and Smelter Area: In: Trace Substances in Environmental Health - IX, D. D. Hemphill, Ed., University of Missouri, Columbia, pp. 207-215.

Provides an example using data collected near Galena, Kansas of methods for distinguishing between different contamination sources of soils and plants with Cd, Pb and Zn where several sources co-exist.

IX. SITE BOUNDARY RECOMMENDATIONS

During this literature review, an attempt was made to define the proper geographical extent of the Cherokee County site. The delineation of the study area limits was performed using information obtained during the site visit, the agency interviews and telephone contacts, collection, and the existing literature review and evaluation. In reviewing the available data on chemical characteristics of the various environmental media in the area, it was not possible to delineate a manageable or appropriate site boundary. The chemical data only provided an overview of the general conditions in a large portion of Cherokee County. Therefore, the location and extent of physically disturbed areas (open shafts, chat piles, subsidence and collapse areas) were used as a primary tool for defining study areas. Based on the information obtained, the Cherokee County site boundary recommendations are presented, as shown on Dwg. 84265-E1 (in back pocket).

The site visit afforded an opportunity to gather first-hand information on site features to aid in the selection of boundaries. It became evident during the site visit that the most noticeable characteristics of the area were of a physical nature, i.e., open shafts, pits, subsidences and collapses, and chat piles. Very few visible indications of chemical contamination were observed. For this reason, the site boundary recommendations were proposed based on a delineation of these physical hazards. Boundary definitions using physical disturbance as the only criteria may not incorporate potential chemical contaminated areas within the study boundaries and should be considered as preliminary until additional data obtained from within and outside the boundaries is available to confirm the boundaries established.

Dr. James R. McCauley of the Kansas Geological Survey served as a guide during the site visit. In his Bureau of Mines report (McCauley, et al., 1983) he provided the results of his hazard evaluation of the Kansas portion of the tri-state mining area. The mining related physical hazards identified in that study were the basis of focus during the site visit. Using the mapping provided with the study, plus additional features noted during the site visit, a total of six different areas within the overall site were delineated. The six "subsite" areas are the Kansas portion of the Waco district, and Lawton, Badger, Galena, Baxter Springs, and Treece, Kansas (Numbered 1-6 on Dwg. 84265-E1). These subsite areas include all known underground lead and zinc mine workings and surface disturbances in the Cherokee County area. It is recommended that these six subsite areas receive the focus of attention during development of the work plan for the remedial investigation.

X. AERIAL PHOTOGRAPHY

Aerial photographs of the site and surrounding areas were compiled and reviewed by Ecology and Environment (1982), McCauley et al. (1983), and EPA Regions VI and VII (1983).

Ecology and Environment (E & E) compiled available photographs from various sources. Photographs were examined for signs of vegetative stress, and observations were field checked.

McCauley, et al. (1983) studied photographs from 1938, 1950, 1973 and 1981 in his study of mine subsidence and related problems. All photographs used for this study were examined stereoscopically.

EPA Regions VI and VII (1983) had aerial photographs of areas near Galena, Baxter Springs, and Treece taken in October, 1982. Photos were interpreted to determine effects and modes of contaminant migration.

The extent of aerial photographic coverage available appears to be sufficient for purposes of a Remedial Investigation. Sets of photos which may be applicable are summarized in Table X-1. Aerial photographs taken in 1981 at a scale of 1:10,800 provide complete stereo pair coverage of the study area. These 1981 aerial photographs could be used to develop aerial mapping at a maximum estimated scale of approximately 1 inch equals 200 feet with 5 foot contour intervals. Due to the low topographic relief in certain areas, the 5 foot contour interval may be insufficient for engineering design purposes and additional aerial photography and mapping will probably be required to provide sufficient detail.

A comparison of aerial photography performed in 1983 with that performed in 1981 could be utilized to assess recent subsidence activity in areas where overlapping aerial coverage exists.

TABLE X-1

AVAILABLE AERIAL PHOTOGRAPHY OF CHEROKEE COUNTY, KANSAS

Reference	Date of Photography	Area of Coverage	Scale	Film
E & E (1983)	10/5/78	Treece, Baxter Springs, Galena, Badger, Lawton, and Associated Areas	1:24,000	Black & White
McCauley, et al., 1983	1938	Not Specified	1:24,000	Black & White
	1950	Not Specified	1:24,000	Black & White
	1973	Not Specified	1:125,000	Color Infrared
	2/81	Entire Mining District in Kansas	1:10,800	Color
EPA Regions IV and VII, 1983	10/7/82	Areas in and around Galena, Baxter Springs and Treece	1:12,000	Color

XI. SUMMARY AND CONCLUSIONS

A. <u>SUMMARY OF EXISTING DATA LIMITATIONS</u>

The following data gaps and limitations to the use of existing data for an RI/FS were identified during this existing literature search and evaluation. The limitations and data gaps discussed are considered particularly relevant to preparation of the Cherokee County site remedial investigation work plan. The limitations and data gaps are presented with reference to the major data types applicable to the site.

1. <u>Geology</u>: Although the basic stratigraphy of the Cherokee County area is fairly well established, there are a few factors which limit understanding. Major fracture orientations, fracture spacings, and fracture openness are not well established in the specific subsite areas. The locations where the deep aquitards are absent have been explored to some extent, but should be further investigated near the subsite areas because of the importance of the aquitard in establishing the degree of separation between the shallow and deep aquifers.

2. <u>Mining Activity:</u> Previous authors have compiled a great deal of information about abandoned mines. However, because of the age of mining activity in the area, it is possible that not all workings have been delineated. Geophysical investigations may be useful in more fully determining the extent of underground workings in specific subsite areas.

3. <u>Shallow Aquifer Hydrogeology:</u> Site-specific groundwater information at subsite areas is very limited. Needed information includes: direction of groundwater flow on a detailed and seasonal basis, permeability, hydraulic interaction between aquifer and mine workings, and groundwater chemistry very near the mine workings.

4. <u>Deep Aquifer Hydrogeology:</u> Much of the data needed for performing the RI/FS are available for the deep aquifer, although additional data

collection will be required to verify existing information. Examination of existing deep aquifer data does not indicate a general affect of mining on deep groundwater quality. Therefore, general investigation of deep aquifer characteristics should not be a high priority. If studies of the shallow aquifer show downward migration of contaminants, then specific detailed studies of the deep aquifer will be necessary.

5. Surface Water: Sixty-five surface water sampling locations related to the Cherokee County study area were identified. Thirteen of these sampling points were located outside Kansas borders on streams which flow into or out of the state. Of the 52 sample locations within Cherokee County, 35 locations, or 65% of the total, were single grab samples. Although the data was generally of good quality, the sample locations and chemical analyses performed were for the purpose of assessing stream quality over a regional area. In terms of remedial investigation/feasibility study requirements, sufficient data to indicate seasonal variability must be collected to identify specific problem areas near subsite areas and allow development, screening, selection, design and construction/implementation of remedial actions for the specific subsite problems.

6. Air Quality: Recent data obtained during July through November, 1983 by KDHE provides information on ambient air quality near the major population centers of Galena, Baxter Springs and Treece, Kansas. These data are limited by chemical analyses which do not include radioactive constituents and fibrous (or asbestos-like materials). Air quality data is not available for assessing specific area sources (i.e. chat piles or tailings ponds) near potential receptors or in evaluating potential human exposure during vehicular use of chat-covered, unimproved roads or residing or working adjacent to chat-covered, unimproved roads.

7. Soil: Insufficient data was obtained to establish natural baseline chemical concentrations and permeability characteristics of native soils in the study area. Native soils may be sources of contamination if subject to historical mining-related contamination or if the parent material contained natural high concentrations of contaminants. The permeability of native soils underlying chat covered areas is important in evaluating the potential for downward migration of contaminants from the chat. Only seven composite samples were identified which provide chemical analyses of heavy metal content in chat piles and tailings ponds in the Cherokee County study area. The seven chat pile and tailings pond samples obtained indicate less than 7% of the total documented chat areas have been sampled. The existing data does not provide information on the chemical variability (horizontally and vertically), nor do the analyses include radioactive constituents or fibrous (or asbestos-like) materials, or agricultural characteristics relative to revegetation potential.

8. Sediment: Only one sediment core analysis obtained from Tar Creek at the Oklahoma-Kansas border during the Tar Creek remedial investigation was available for the Cherokee County study area. Additional sediment sampling is required to assess the chemical characteristics of sediment in the study area and evaluate potential long-term effects on water quality and aquatic organisms.

9. Study Area Boundaries: The study area boundary was revised into six subsite areas using the physical extent of surface and underground mining disturbances reported by McCauley (1983). The existing chemical sample data provided only a general survey of environmental conditions and could not be used in refining the study area boundaries. Boundary definition using physical disturbance as the only criteria may not incorporate potential chemical contaminated areas within the study boundaries and should be considered as preliminary until additional site specific data is available to confirm the boundaries.

10. Aerial Photography: Aerial photographic coverage in the Cherokee County study area includes photographic dates spanning the years 1938 to 1982. Aerial photographs taken in 1981 at a 1:10,800 scale provide complete stereo pair coverage of the study area. It is estimated that aerial mapping could be performed at a scale of approximately 1 inch equals 200 feet with 5 foot contour intervals using this mapping. Due to the low topographic relief in certain areas, the 5 foot contour interval and limitation on the scale may be insufficient for engineering design purposes.

B. CONCLUSIONS

The data reviewed and assessed for this study included geological, groundwater, surface water, air, soil, biological, sediment, and aerial photographic information. In general, the data was from widely spaced locations, at minimal sampling frequency, and included inconsistent and/or incomplete chemical analysis with respect to known or suspected lead and zinc mining contaminants.

Due to the regional nature of the data, insufficient environmental sampling data is available to characterize the extent of contamination at and/or contaminant migration from specific sites, or to allow the development, screening, selection, design and implementation of specific remedial actions.

Due to the size of the mining disturbance within Cherokee County, it is felt that the Remedial Investigation work plan should require additional sampling to identify, if possible, specific problem areas, the resultant contaminated media, and provide sufficient information necessary to develop, evaluate, select, design and implement onsite and offsite remedial actions.

APPENDIX I

SUMMARY OF AGENCY CONTACTS

Agency	Location	Individual Contacted	Type of Contact	Date Contacted	Contacted By
KS Dept. of Health and Environment	Topeka, KS	John Irwin	Visit	10/9/84	ETM
		Ray Beurgin	Telephone	10/25/84	ETM
		Don Snethen	Visit	10/9/84	ETM
		Howard Spiker	Visit	10/9/84	ETM
		Don Carlson	Visit	10/9/84	ETM
		Larry Knoche	Visit	10/9/84	ETM
		Dennis Murphy	Visit	10/9/84	ETM
		Joseph Hollowell	Visit	10/9/84	ETM
		Bill Mowrey	Telephone	10/9/84	DT
U. S. Geological Survey	Lawrence, KS	Hugh Bevans	Visit	10/10/84	ETM
Kansas Geological Survey	Lawrence, KS	Larry Hathaway	Visit	10/10/84	ETM
		Jim McCauley	Visit	10/11/84	ETM
University of Kansas Medical School	Kansas City, KS	Dr. John Neuberger	Visit	10/11/84	ETM
Kansas Geological Survey	Lawrence, KS	Jerry Welch	Visit	10/11/84	ETM
EPA Region VII	Kansas City, MO	Alice Fuerst	Visit	10/12/84	ETM
		Wolfgang Brandner	Visit	10/12/84	ETM
U. S. Bureau of Mines	Rolla, MO	Wally Dressel	Visit	10/9/84	EHB
MO DNR - Geology and Land Survey	Rolla, MO	Mike McFarland	Visit	10/9/84	EHB
U. S. Geological Survey	Rolla, MO	Jim Barks	Visit	10/10/84	EHB
EPA Region VI	Dallas, TX	Stan Hitt	Visit	10/24/84	REM

ETM - Emory T. McLean, SRW Associates Inc.
EHB - Earl H. Brown, SRW Associates Inc.
DT - Debora Thompson, SRW Associates Inc.
REM - Richard E. Moos, CH2M Hill
DW - Duane Whiting, CH2M Hill

Appendix I (continued)

Agency	Location	Individual Contacted	Type of Contact	Date Contacted	Contacted By
University of MO-Rolla	Rolla, MO	Central Library	Visit	10/10/84	EHB
MO Southern State College (Tri-State Mining District Map Repository)	Joplin, MO	Charles Nodler	Visit	10/11/84	EHB
Ecology & Environment Inc.	Kansas City, KS	Debbie Kopsick	Visit	10/12/84	EHB
KS Biological Survey	Lawrence, KS	Ronald McGregor Paul Liechi	Telephone Telephone	10/9/84 10/9/84	DT DT
KS Fish & Game Comm.	Pratt, KS	Bob Hartman Daryl Moti Bill Laird	Telephone Telephone Telephone	10/10/84 10/10/84 10/10/84	DT DT DT
MO Dept. of Conservation	Jefferson City, MO	Staff	Telephone	10/10/84	DT
USDA-SCS Cherokee Cty.	Columbus, KS	Pat Broyles	Telephone	10/24/84	ETM
U.S.G.S.	Oklahoma City, OK	David Parkhurst	Visit	Week of 10/8/84	DW
Oklahoma Water Resource Bd.	Oklahoma City, OK	Vahan Hoonanian	Visit	Week of 10/8/84	DW
Oklahoma Geological Survey	Norman, OK	Charles Mankin Bill Rose	Visit Visit	Week of 10/8/84	DW
Oklahoma State University (Water Quality Research Lab)	Stillwater, OK	Dr. Gene Maughan Dr. S. L. Burkes	Visit Visit	Week of 10/8/84	DW

ETM - Emory T. McLean, SRW Associates Inc.
EHB - Earl H. Brown, SRW Associates Inc.
DT - Debora Thompson, SRW Associates Inc.
REM - Richard E. Moos, CH2M Hill
DW - Duane Whiting, CH2M Hill

APPENDIX II

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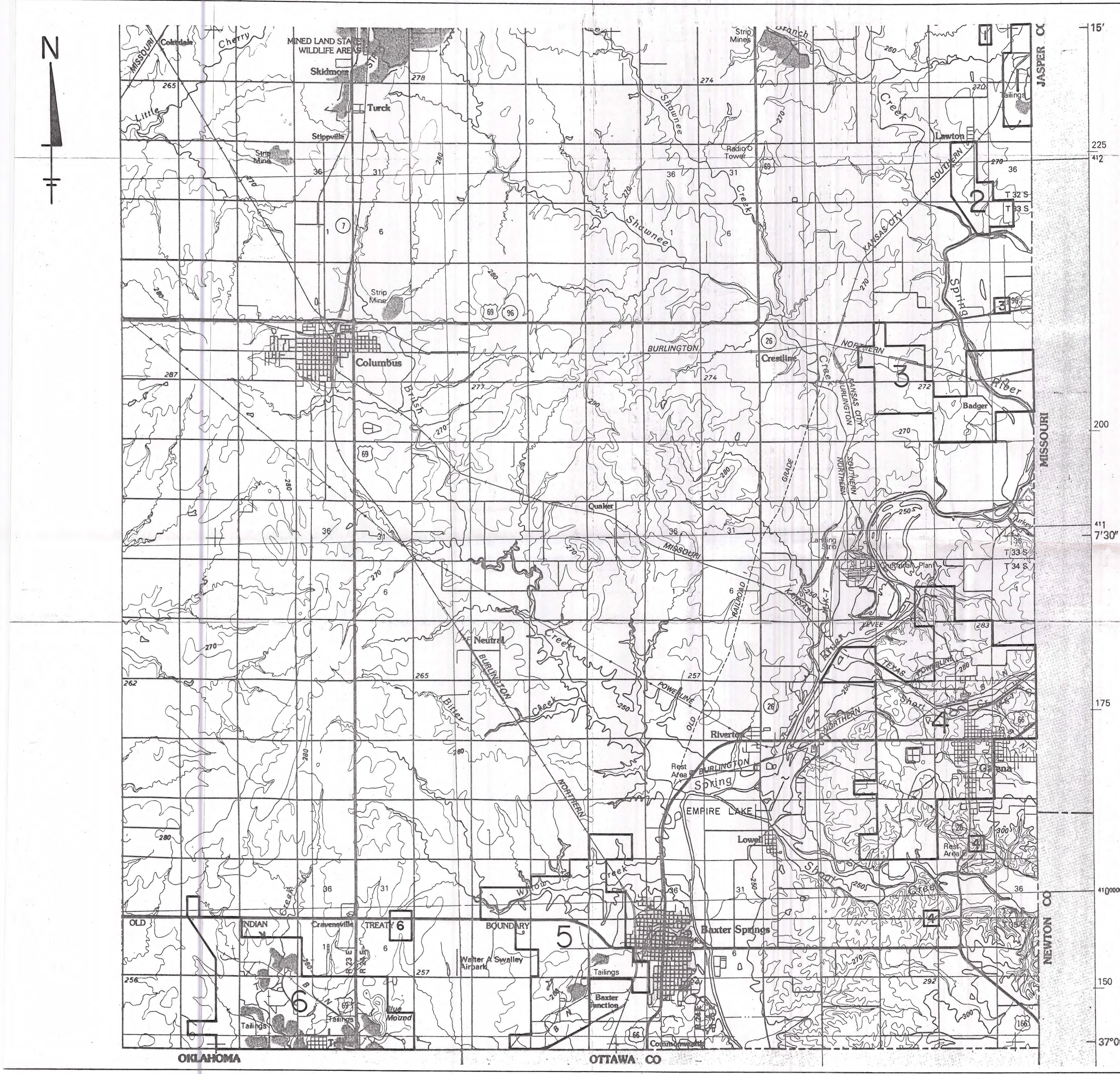

SUBSITE LEGEND:

1. WACO AREA
2. LAWTON AREA
3. BADGER AREA
4. GALENA AREA
5. BAXTER SPRINGS AREA
6. TREECE AREA

DATE	SYM	REVISION RECORD	DR.	CK.

SRW ASSOCIATES INC.

SCALE: 1 : 50,000	APPROVED BY:	DRAWN BY: B. SNYDER
DATE: OCT. 25, 1984		CHECKED BY:

CHEROKEE COUNTY, KANSAS
PORTION OF THE TRI-STATE MINING DISTRICT

SUBSITE BOUNDARY RECOMMENDATIONS

SHEET NUMBER

DRAWING NUMBER 84265 - E1